SPACE BENEFITS

THE SECONDARY APPLICATION OF AEROSPACE TECHNOLOGY IN OTHER SECTORS OF THE ECONOMY

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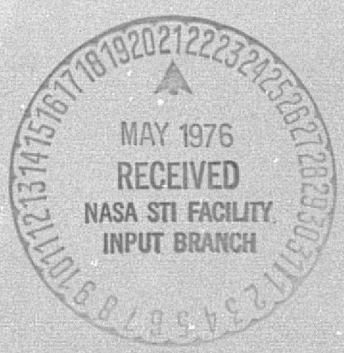

NASA BENEFITS BRIEFING NOTEBOOK

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- Prepared by -

Program for Transfer Research and Impact Studies
Industrial Economics Division
Denver Research Institute
University of Denver

PREFACE

This "Benefits Briefing Notebook" has been prepared for the NASA Technology Utilization Office by the Denver Research Institute, "Program for Transfer Research and Impact Studies," to provide the Agency with accurate, convenient, and integrated resource information on the transfer of aerospace technology to other sectors of the U.S. economy. Portions of this notebook will be updated or expanded on a timely basis as new materials become available.

The contents of this notebook are divided into two sections: (1) Benefit Cases and (2) Indexes. The transfer examples section is subdivided into eleven subject areas; the Table of Contents identifies those areas. Each subsection presents one or more key issues of current interest in the discrete transfer cases related to each key issue. Finally, additional transfer examples relevant to each subject area are presented. Pertinent transfer data are given at the end of each example (viz., the communication link; the Transfer Example File and individual case numbers; and the date of the latest information used).

Transfer examples may be selected for speeches, articles, or other purposes on the basis of factors such as location, audience composition, or subject matter by using one or more of the four indexes.

Since we are evolving this document and plan to add and update its contents, a constructive critique would be beneficial.

Louis Mogavero, Acting Director
Technology Utilization Office

TABLE OF CONTENTS

A. MANUFACTURING CONSUMER PRODUCTS

Key Issues

a. Consumer product R&D: 1973 McGraw-Hill Economics Department survey of industrial R&D expenditures indicated continuing decline as % of sales (2.5% of sales in 1972, 2.4% in 1973, projected 2.3% by 1976) and significant shift from new product or process development to improving products or processes. 44% of manufacturers surveyed reported product improvement as main R&D goal and 73% did not anticipate a technological or basic research breakthrough by 1976. Previous 1972 survey indicated that new products would account for 18% of total sales in 1975, 1973 survey now indicates they will account for 13% in 1976. (A-1)

b. Productivity: Average annual increase in output per man-hour was 3.1% (1955-1966), 1.7% (1967-1970), 3% (1971-1972). Bureau of Labor Statistics estimates that decrease of 0.1% in average productivity between 1970 and 1980 would cause GNP to be $60 billion less than potential. Productivity expert Professor John Kendrick (George Washington University) stated that 1967-1970 slump was due to slow-down in government funding as % of GNP, which peaked in 1964, and since then "growth in the stock of knowledge has been decelerating." Upturn in 1971 attributed by Business Week (1/1/72, p. 36) to new worker hiring lag at beginning of business boom, only a short-term effect. (A-4)

A. MANUFACTURING CONSUMER PRODUCTS

*A-1 Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed. . . . product purchased by B.F. Goodrich Co. (Ohio) and regularly used for consumer product R&D. . . . applications include analyzing tire designs and causes of tire fatigue, identifying tire design and construction flaws, and investigating how heat shortens service life for V-belts, shock mounts, brakes and rubber bearings. . . . scanner enables researchers to observe and record heat build-up during product testing so designs or production processes can be improved. . . . 1973 R&D funding by rubber products industry was about $200 million (1.1% of sales), large part directed toward product improvement. (Customer/contractor, TEF 398, Case No. 70001, 8/74)

A-2 Management method for R&D programs: developed for Marshall. . . . used by The Upjohn Co. (Michigan) to develop management method for its pharmaceutical research programs. . . . saved Upjohn substantial man-hours. (TB/TSP, TEF 452, Case No. 60860, 8/74)

A-3 Composite materials data: compiled for Marshall. . . . used by Babcock and Wilcox Co. (Ohio) in designing composite products. . . . orders of nearly $1 million in 1973. . . . products used in golf club shafts and business machines. (Trade journal/TSP, TEF 490, Case No. 87986, 2/74)

*A-4 Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. (Alabama). . . . integral part of industrial monitoring system developed by SCI. . . . entire industrial system similar to Saturn instrument monitoring system. . . . SCI system installed in most U.S. textile weaving mills built between 1968 and 1971, 17 installations by SCI in price range $65,000 to $100,000, at least 4 more installed by ex-SCI employees working for West Point-Pepperell, Inc. (Georgia). . . . product line sold to Swiss company in 1971, with same technology used in many new textile weaving mills worldwide (particularly, Poland, France, Belgium and U.S.). . . . system monitors loom operator performance and is wholly responsible for productivity increases over 1%, generally in 2-6% range. . . . annual national productivity increase was 1.7% between 1967 and 1970, 3% before and after that time period. (Contractor, TEF 119, Case No. 04793, 9/74)

A-5 Contamination control handbook: compiled for Marshall. . . . used by Ortho Pharmaceutical Co. (New Jersey) to design better contamination control facilities for birth control pill production. . . . increased worker productivity . . . . used by Kentucky Electronics, Inc. (Kentucky) to improve two key production steps for consumer electronics (mainly color television components for RCA, Westinghouse and Zenith products), degreasing and drying operations now done with fluids and processes described in handbook. . . . improved product quality and productivity, with annual sales over $7 million. (TB/TSP, TEF 262, Case Nos. 31286, 39662, 9/74)

* Denotes transfer case related to Key Issue.

A-6 Method to improve electrical resistors with hydrogen: developed for Headquarters. . . . used by Zeller Corp. (Ohio) to develop automated process for resistor spark plug production. . . . automation saves 4 cents per unit and over 500,000 sold annually since 1972. (SBA/TSP, TEF 468, Case No. 88432, 8/74)

A-7 Optical alignment training manual: compiled by Marshall. . . . incorporated into standard operating procedures at Eastman Kodak Co. (New York) for aligning optical testing instruments. . . . accuracy improved. (TB/TSP, TEF 208, Case No. 32414, 8/74)

A-8 Intumescent fire retardant coatings: developed by Ames. . . . used, under NASA license, by Avco Corp. (Massachusetts) to develop commercial product line. . . . more than 50,000 sq. ft. of the intumescent sheeting product sold monthly to major manufacturer of hoses. . . . used as protective cover on fuel hoses for inboard pleasure boats. . . . Avco working with Boating Industry Association and U.S. Coast Guard to develop additional intumescent coatings for pleasure boat applications such as fuel tanks and engine compartment walls. . . . improved fire safety for boating. (License, TEF 554, Case No. 108481, 2/75)

A-9 Dry lubricant coating processes for metals: research need identified in quality control study conducted for Headquarters by General Magnaplate Corp. (New Jersey). . . . company developed and patented 4 processes to bond dry lubricants, such as Du Pont's Teflon, on metal surfaces for space applications . . . . many components for Apollo, Viking, Skylab, and Shuttle coated by General Magnaplate. . . . commercial coating services introduced; annual sales are $1.8 million. . . . over 600 manufacturing clients include GE, IBM, RCA, Westinghouse, Polaroid, and ITT. . . . applications include production equipment for hundreds of household items such as molded plastic products, dog biscuits, birth control pills, and food, as well as products such as computer components, office equipment, packaging machinery, turbines, valves and racing car components. . . . coated production equipment enables longer wear life, higher operating speeds, and cleaner operation. . . . increases productivity and lowers unit cost. . . . two Japanese companies, including Mitsubishi Corp., and one Israeli company licensed to use processes. (Contractor, TEF 575, Case No. 109338, 5/75).

Other Relevant Examples:

B-9 (lubricant deposition process); B-19 (flammability tests of home furnishings); B-23 (spun metal fibers for web filters); C-5 (fabric metallizing process); F-2 (product safety); H-11 (automobile fuel R&D); I-5 (home safety product); K-3, K-4, K-5 and K-6 (automobile design and production); K-7 (studless winter tires); Q-4 (lubrication handbook)

B. MANUFACTURING CAPITAL GOODS

Key Issue

Balance of trade for capital goods: In 1973, U.S. exported capital goods worth $21.5 billion and imported $7.5 billion. Exports of electrical machinery and electronic components accounted for $3.5 billion, more than any other classified capital goods. U.S. supplied over two-thirds of growing world market for microelectronic components. Market share maintained by continually advancing the state-of-the-art of microelectronic component production technology so that productivity is increased. Productivity depends on yield which is improved by reducing the percentage of components spoiled during production. (B-1)

B. MANUFACTURING CAPITAL GOODS

*B-1 Microelectronics production quality assurance: NASA established reliability program and procurement standards for microelectronic products in 1964 to assure best manufacturing practices would be used by suppliers. . . . introduced concept of Certified Production Line (CPL) so that entire production lines, rather than products themselves, were certified for NASA procurement after vendor had established quality control practices and in-house evaluation methods to satisfy NASA inspection teams. . . . CPL approach later adopted by DOD which developed, with NASA, certification standards. . . . many major microelectronics manufacturers configured standard production lines to be certified for space or defense procurement and now produce commercial units from these lines. . . . widespread impact by increasing productivity for commercial products on world market. . . . one vendor increased yield by 20% after modifying production practices for certification (1-2% increases very valuable in the industry). . . . Marshall obtained one of first scanning electron microscopes (SEM) ever built and developed SEM inspection techniques to analyze failure modes for microelectronics. . . . provided failure analysis reports to microelectronic vendors and encouraged manufacturers to use SEM for same purpose. . . . SEM's now widely used in U.S. microelectronics industry. . . . largest producer of microelectronics, Texas Instruments (Texas), with annual sales over $1 billion, is certified by NASA and used 3 SEM's for quality assurance and failure analysis. . . . NASA standards used in key production steps for all TI products. (Contractor, Industrial Products and Practices, DRI, 2/73)

B-2 Infrared scanner and television display: operational unit developed for Marshall. . . . contractor employees founded Dynarad, Inc. (Massachusetts) to market unique product line of IR scanners. . . . units display heat picture on TV screen. . . . over $2 million in total sales, unit price range $6,500 to $25,000. . . . customer applications include maintenance inspections, quality control, and research in several industries (steel, aluminum, petrochemical, rubber, nuclear fuels, aircraft and electric power) as well as medical diagnoses such as breast cancer. (Personnel/contractor, TEF 398, Case No. 70001, 8/74)

B-3 Ultrasonic nondestructive testing techniques: developed for Marshall and Johnson by Automation Industries, Inc. (Connecticut). . . . company had over $2 million in contracts to produce innovative NASA equipment in past few years and has "had commercial spin-offs of several times that amount". . . . for example, Marshall funded the development of company's laboratory prototype into operational ultrasonic Delta Manipulator which Automation then marketed . . . . uses multiple transducers for significant improvement in speed and accuracy. . . . more than 25 manufacturers purchased between 1 and 100 Manipulators @ $800. . . . larger number of firms fabricated in-house versions. . . . widely used for quality control inspection of aircraft components and steel pipe manufactured for petrochemical applications. . . . Automation has $50 million annual sales of ultrasonic test equipment for quality control in steel, railroad, aircraft, nuclear reactor, automotive, and tubular products industries. (Contractor, TEF 387, Case No. 59201, 8/74)

* Denotes transfer case related to Key Issue.

B-4 Nondestructive testing handbook: developed by Marshall. . . . ultrasonic techniques in handbook provided 10-30% of input to development of in-house quality control procedures at Aluminum Company of America (Pennsylvania) . . . . ultrasonic testing routinely done for wrought aluminum products at Alcoa plants. . . . ultrasonics faster, better resolution than other NDT methods in finding flaws, very important link to fracture mechanics since brittle fracture can start at flaws left by fabrication process. (TUO conference, TEF 381, Case No. 57802, 8/74)

B-5 Contamination control handbook: compiled for Marshall. . . . used at Xerox Data Systems (California) to improve contamination control in production of computer peripherals such as disc files. . . . reduced cost of contamination control and significantly reduced quality control failure rate caused by contamination. (TB/TSP, TEF 262, Case No. 33050, 10/72)

B-6 Surface finishing method for nickel alloys: developed for Marshall. . . . standard process at Westinghouse Corp. (Pennsylvania) since 1970 to finish components for gas turbine electric generators. . . . turbines up to 100 megawatts. . . . significant time and cost savings over previous method. (TB/TSP, TEF 198, Case No. 29518, 8/74)

B-7 Inert-gas welding enclosure: developed by Lewis. . . . used by Communications Satellite Corp. (District of Columbia) to fabricate microwave components for satellites and ground stations. . . . made it possible to use very lightweight metals for components and reduce production time ten-fold. (TB/TSP, TEF 189, Case No. 19795, 8/74)

B-8 Fluidic controls: developed by Lewis for rocket engines. . standard controller on automatic metalworking lathes produced by Bardons and Oliver, Inc. (Ohio) since 1967. . . . only fluidic-controlled lathes on market. . . . 125 sold in price range $40,000 to $80,000. . . . fluidic controls are half the cost of electric controls, also more reliable and maintainable. (TUO conference, TEF 193, Case No. 101902, 8/74)

B-9 Lubricant deposition process: developed for Goddard by Ball Brothers Research Corp. (Colorado). . . . process commercialized by BBRC into VacKote line of several hundred lubricant products. . . . 1973 sales $1 million and annual growth 25%. . . . over $100,000 from license royalties. . . . 300 industrial customers. . . . customer examples: coating for glass industry molds increases production efficiency 5% and eliminates prior fire hazard; protective film coating for movie camera film cartridges improves performance and reduces film breakage; lubricant for electric motor brushes in vacuum cleaners, electric shavers, and car air conditioners increases service life; and lubricant for computer peripheral equipment increases efficiency. (Contractor, TEF 201, Case No. 42849, 8/74)

B-10 Fracture toughness tests: developed by Lewis. . . . used by Aluminum Company of America (Pennsylvania) to provide fracture toughness guarantee for high-strength alloy products. . . . critical design parameter for Alcoa customers who use these alloys to fabricate aircraft components, chemical processing equipment, or liquefied natural gas containers on ocean tankers. . . . reduces structural failures. (Professional society, TEF 451, Case No. 101901, 8/74)

B-11 Thermal expansion properties handbook: compiled for Marshall. . . . used extensively at Eastman Kodak Co. chemical plant (Tennessee) in design and materials selection for new hydrogen production facility worth over $500,000 . . . . saved 25% of design cost and significant amount of construction cost . . . . also used to select better materials for catalytic cracker and heat exchanger. (TB/TSP, TEF 321, Case No. 32416, 3/71)

B-12 Weld strength prediction method: developed for Marshall. . . . used at Eastman Kodak Co. chemical plant (Tennessee) to improve safety at little cost. . . . eliminated hazard of rupturing pipes that contain chemicals. (TB/TSP, TEF 359, Case No. 41946, 3/71)

B-13 Fan noise reduction method: developed for Ames Quiet Engine Program. . . . used by Kennecott Copper Corp. (Utah) to design inexpensive acoustic panels for fans in copper refineries. . .. enabled company to comply with noise level regulations set by Occupational Safety and Health Administration (OSHA) . . . . significant savings compared to alternative of replacing older fans. (TB/TSP, TEF 476, Case No. 81646, 8/73)

B-14 Mass flowmeters for low gas flow: developed to meet specifications of Johnson Apollo subcontractor by Tylan Corp. (California). . . . Tylan introduced gas flowmeter as commercial product in 1968. . . . product now used extensively in U.S., Europe, and Japan for process control and manufacture of semiconductors, as well as in petrochemical production, medical instrumentation, heat transfer devices and thermodynamic analysis. . . . since initial NASA market in 1965, growth in annual sales from $300,000 to $3,000,000, employment up from 20 to 80. . . . entire business based on fallout from Apollo Program. (Subcontractor specifications, TEF 563, Case No. 109332, 5/75)

B-15 Technique for reducing noise in radio amplifiers: developed for Headquarters . . . . used by GTE Sylvania, Inc. (California) to improve rf amplifier product by lowering "electrical noise". . . . saved research time and reduced operating costs. . . . amplifiers used in high sensitivity, low noise military receivers. (TB/TSP, TEF 553, Case No. 58826, 3/75)

B-16 Specification guidelines for hybrid microcircuits: compiled by Marshall. . . . used by Bell & Howell Co. (Connecticut) to develop new manufacturing process for epoxy mounting of semiconductors on substrates. . . . technique now used in production of part of company product line. . . . reduced operating and material costs. (Personal contact/TSP, TEF 556, Case No. 91196, 4/75)

B-17 Temperature and solvent resistant sealant: developed for Marshall. . . . used by Weed Instrument Co. (Texas) to develop new sensing component for temperature control product line. . . . product accuracy improved, contributing to substantial increase in company's annual sales. . . purchased by various industries to control temperature of plant process equipment (TB/TSP, TEF 541, Case No. 90086, 3/75)

B-18 Guidelines for fabrication of hybrid microcircuits: compiled for Marshall . . . . used by Watkins-Johnson Co. (California), manufacturers of microwave communications systems, to improve processing techniques in assembly of microcircuits. . . . improved product quality and production yields; increased marketability and sales. . . . used by Harris Semiconductor Div. of Harris Corp. (Florida) in development of integrated circuit packages. . . . reduced operating costs. . . . packages sold to electronic equipment manufacturers for use in computer control and communication equipment. (TB/TSP, Trade show/TSP, TEF 501, Case Nos. 83756, 101726, 4/75)

B-19 Flammability tests of home furnishings: conducted for TUO by Battelle Columbus Laboratories to compare performance of aerospace materials with conventional furnishing materials in full-scale bedroom fires. . . . report used by Monsanto Co. (Missouri) to design flammability tests of fire retardant chemicals and other company products used in the construction industry. . . . also used by Owens-Corning Fiberglas Corp. (Ohio) to help in evaluating flammability data from in-house test program to develop new markets for company products . . . . used by Baychem Corp., Mobay Chemical Co. (Pennsylvania), to design fire tests and evaluate data for in-house program to improve fire resistance of polyurethane foams; major manufacturer of chemicals used to produce foams. (Contact/contractor, NTIS, TEF 539, Case Nos. 107043, 107044, 107046, 1/75)

B-20 Electronic power dividers and switching components: developed for Johnson Apollo communications systems by Transco Products, Inc. (California). . . . developed into commercial products by Transco. . . . enabled design of compact, hermetically sealed, highly reliable electronic components. . . . applications in aerospace and nonaerospace microwave communications equipment. (Subcontractor, TEF 562, Case No. 109336, 5/75)

B-21 Standards for material handling equipment testing: developed for Johnson . . . . regularly used by Goodyear Atomic Corp. (Ohio), ERDA contract operator of major uranium gaseous diffusion facility, during internal safety code inspections and safety report preparation. . . . provides more detailed information than safety code for some equipment. . . . only UF_6 diffusion in U.S.; occupies 3,000 acres, with 38 large buildings containing many units of material handling equipment. (TB/TSP, TEF 572, Case No. 58958, 4/75)

B-22 Apollo Program management techniques: developed for Johnson for Rockwell International Corp., Space Div. . . . used by RI's Rockwell-Standard Div. (Michigan), major producer of truck and bus components such as axles and transmissions, to manage product design and development processes. . . . enabled significant improvements in personnel evaluation procedures, standardization of product and component test methods, task scheduling, design control procedures, and other management tasks. . . . initiated use of computerized management information system for product warranty payment data. . . . annual RI sales for automotive products about $1 billion. (Personnel/contractor, TEF 573, Case No. 109337, 4/75)

B-23 Spun metal fibers for web filters: identified by Marshall contractor as needing further development for space applications. . . . developed by Hydraulic Research and Manufacturing Co. (California) and supplied to Apollo Program contractors. . . . commercially available from HR since 1971. . . . annual sales over $500,000: market expected to double in 5 years. . . . filter applications include chemical processes for photographic film and synthetic fibers, nuclear reactors, marine hydraulic systems, and subsurface blowout valve systems on offshore oil rigs. (Contractor report, TEF 564, Case No. 109330, 5/75)

Other Relevant Examples:

A-3 (office equipment); A-9 (production machinery lubrication); C-1 (energy conservation equipment); D-3 (dispatch computers, electric power); D-6 (nuclear power plant equipment design); D-7 (steam turbine, steam generator and high temperature gas-cooled reactor design); D-9 (nuclear power plant design); E-12 (manufacturing contamination prevention); F-2 (farm tractors and implements); H-2, H-3 and I-6 (LNG storage and transfer facilities); H-4 and H-5 (process control systems); H-6 (heat pipes); H-10 (gasoline vapor condenser); J-5 (flat conductor cable); M-3 (production inspector training); M-5 (decontamination procedures); O-4 (soldering school); O-6 (R&QA training); O-7 (instrument training); Q-3 (electron tubes)

C. NEW CONSUMER PRODUCTS AND RETAILING

Key Issues

a. New product introduction: New products have been a major source for corporate growth. Industrial trend is now toward introducing fewer new products and reducing production costs to maintain profitability (see Key Issue A-a). Booz, Allen and Hamilton estimates that only 2% of new product ideas are successfully commercialized. A recent study of 500 successful innovations showed 75% were based on market demand or production need, rather than technical feasibility. Even with market demand, a new consumer product may not be profitable if return on investment is inadequate. Dr. T. R. Hopkins, president of Gulf Research and Development Co., said in 1973 speech that product research is out-pricing itself since research costs are 10% of the investment to manufacture a new product. (C-1)

b. Automation in department store sales: Retail sales by department stores were $37.3 billion in 1970 and will be about $55.5 billion in 1974; this represents 10% of total retail sales. Between 1970 and 1974 there was a 30% increase in department store sales per employee. One factor in this productivity increase is the rapid proliferation of computerized point of sale (POS) equipment such as cash register and credit authorization terminals. Over 250,000 POS terminals are being used by retailers. Many of the terminals are linked to approximately 75 major, on-line computer systems that have been installed by department store chains such as J.C. Penney and Montgomery Wards. POS equipment sold in 1973 had an estimated value of $70 million; expected payback time for the equipment cost is 3 to 4 years. Advantages include reduced operating costs, improved inventory control, more detailed merchandising information, and faster, more accurate sales transactions. (C-9)

C. NEW CONSUMER PRODUCTS AND RETAILING

*C-1 Heat pipe technology: developed for NASA by Los Alamos Scientific Labs and others. . . . based on availability of NASA R&D results from a Regional Dissemination Center, Isothermics, Inc. (New Jersey) was formed in 1971 to market heat pipe products. . . . five product lines introduced and successful . . . . $700,000 sales in 1972, over $1.5 million sales in 1974. . . . over half of sales are for Air-O-Space and Thermo-Coil, heat pipes that recover waste heat from furnace flue gas. . . . Air-O-Space for home furnaces, 10,000 sold in 1974 @ $100. . . . Thermo-Coil for industrial furnaces, dryers, etc., just introduced, projected annual market doubling and $2 million sales in 1976. . . . products increase heat efficiency by 8-10%, relevant to new consumer demand. . . . Isothermics capturing large market share early in trend toward energy conservation equipment. (RDC-TAC, TEF 197, Case No. 83601, 9/74)

C-2 Anti-fog compound: developed for Johnson. . . . prevents condensation fogging on transparent surfaces. . . . more than 60 NASA licenses issued. . . . sold by Western Fire Equipment Co. (California) for fire fighters' face shields, air masks and for protective goggles. . . . marketed by others for eyeglasses, diver's masks, ski goggles. . . . known sales exceed $500,000. (TB/TSP, TEF 423, Case No. 81857, 8/74)

C-3 Rogallo airfoil design: developed by Langley Research Center for rocket recovery. . . . used by Free Flight Systems (California) and others to design hang gliders for recreational use. . . . Rogallo design used on 90% of all hang gliders. . . . Free Flight Systems is largest manufacturer of hang gliders. . . . 3,000 sold @ $500. . . . rapidly growing sport. (Personal contact/ JPL, TEF 499, Case No. 101900, 8/74)

C-4 Battery-powered hand tools: developed for Johnson by Black and Decker (Maryland). . . . commercialized by B & D into line of 6 cordless power tools for home consumer (including 1/4" drill, 3 models of grass shears, 2 shrub and hedge trimmers). . . . direct improvement over previous line. . . . sales figures not available. (Contractor, TEF 300, Case No. 33607, 8/74)

C-5 Aluminized mylar: basic patent by National Research Corp. in 1962. . . . first applications developed for Lewis (Echo I, spacecraft, space suits) . . . . commercial product, SPACE blanket, introduced by NRC in 1964. . . . NRC became Norton Co. division and metallized process extended to provide fabric coating service for companies, such as McGregor-Doniger, Inc. (New York), making ski parkas, coats, sleeping bags, life raft canopy. . . . annual sales for Norton coating service and products over $2 million. . . . division sold to King-Seeley Thermos Co. (Massachusetts) in 1971. . . . products and process still being marketed, sales figures not available. (Contractor, TEF 160, Case No. 37434, 8/74)

* Denotes transfer case related to Key Issue.

C-6 Active filter circuit design method: developed for Marshall. . . . circuitry and design procedures utilized by Computer Image Corp. (Colorado) in development of its Scanimate computer. . . . contributed to unit cost reduction from $350,000 to $300,000 each. . . . 1973 sales $900,000. . . . 1973 service income $2 million. . . . product used to generate computer animation for television advertising for Pontiac, Wards, Amoco, Kellog, Black Label and Time magazine. (SBA/TSP, TEF 436, Case No. 56028, 8/74)

C-7 Inflatable/nontippable life raft: developed by Langley for ocean recovery of astronauts. . . . commercialized by Winslow Co. (Flordia) in conjunction with the individual who received exclusive NASA license to practice the invention. . . . survival equipment on pleasure boats/aircraft, U.S. Coast Guard vessels and some overseas airliners. . . . three models in price range $210 to $1,430, 1974 sales $70,000. . . . company's life raft improves chance of safe rescue by providing radar reflective, thermally insulated metallized cloth cover. . . . cloth produced by King-Seeley Thermos Co. using other NASA technology. (License, TEF 131, Case No. 02440, 9/74)

C-8 Chlorate candle oxygen supply: improved for Johnson. . . . Regional Dissemination Center provided information on chlorate candle technology to Pyronetics, Inc. (California). . . . information used to develop portable welding torch product that incorporates chlorate candle oxygen supply. . . . approximately 100,000 units sold since 1972, retail price $30. . . . product weighs 7 lbs. and gives a 5,000°F flame. . . . home and hobby applications. (RDC-WESRAC, TEF 466, Case No. 87123, 8/74)

*C-9 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (California). . . . used by TRW Data Systems (California) to develop computerized retail sales systems for department store chains. . . . largest supplier of such systems; has installed about 60 on-line computer systems (80% of total installations), with over 50,000 point of sale (POS) terminals connected to these systems. . . . typical system with 1,000 credit authorization terminals in 175 stores costs about $1.5 million; average improvements over nonautomated methods include 95% reduction in purchases on bad debt accounts, 75% reduction in fraud purchases, 20% cost savings in payroll for authorization employees, and 33% reduction in telephone calls. . . . systems with POS cash register terminals also provide improved inventory control, more accurate and faster sales transactions, more detailed merchandising information, and better sales data for management analysis. . . . TRW customers include Montgomery Wards, May Co., Neiman-Marcus, J.C. Penney, Rich's, Burdine's, Hudson's Bay Co., and many more. (Contractor, TEF 465, Case No. 104260, 10/74)

* Denotes transfer case related to Key Issue.

C-10 Polyurethane-silicone plastic foam: developed for Ames Integral Passenger Aircraft Seat Program. . . . produced commercially as TEMPER FOAM by former contractor employee. . . . used by Becton Dickinson and Co., Protective Products Div. (Texas) as padding in football helmet products. . . . compared to conventional helmet padding, reduces shock from impact by 340%. . . . since market introduction in October 1974, approximately 2,000 helmets sold @ about $20 each. . . . sales mostly to school teams; also purchased by Dallas Cowboys. (Customer/personnel/contractor, TEF 570, Case No. 109334, 4/75)

C-11 Quartz crystal oscillator for Apollo Central Timing Equipment: developed for Johnson contractor by General Time Corp. (Illinois). . . . provided stable primary time base and related integrated circuits for all Apollo mission timing functions. . . . GT used the revolutionary new timekeeping base, now called Quartzmatic, and integrated circuits to develop line of consumer clocks and watches. . . . maintain accuracy to within 1 minute per year. . . . produced by GT Westclox and Seth Thomas Divisions in retail price range of under $30 to over $250. . . . popular new consumer product. (Subcontractor, TEF 560, Case No. 109328, 5/75)

C-12 Highly reliable flashlight switch: developed for Langley by ACR Electronics; now Chromalloy American Corp., Chromalloy Electronics Div. (Florida). . . . used in all manned spacecraft. . . . repackaged and introduced by Chromalloy as consumer flashlight, "5 Year Light". . . . long shelf-life guarantee possible because switch will not corrode and cause battery drain. . . . typically stored for emergency use. . . . over 2 million units sold @ $6 to $7 each. (Contractor, TEF 566, Case No. 109333, 5/75)

Other Relevant Examples:

A-2 (golf club shafts); A-6 (resistor spark plugs); F-4 (high protein flour); F-5 and F-7 (packaged food quality); F-8 (beef merchandising innovation); F-9 (freeze-dried food); F-10 (frozen food quality); I-2 (geodesic domes); I-5 (home safety device); K-4 (automotive electronic ignition); K-5 (automotive gas turbine engine); P-12 (Paper Money Identifier)

D. ELECTRIC UTILITIES

Key Issues

a. Pollution control: "The environmental crusade was the costliest phenomenon ever to batter the nation's electric utility industry" (Electrical World, 1974). Capital and operating costs for air pollution control were $1.7 billion in 1971 and $2.5 billion in 1973. (D-1)

b. Dispatch computers: Electric utility market for computers growing at 20% annually; major trend is installation of real-time digital computers for dispatch and control of bulk power supply systems (interconnected generating stations). Digital dispatch provides economic, reliable operation of these power pools and prevents recurrance of 1965 Northeast Blackout. Approximately 20 dispatch computer systems installed or under contract. (D-3)

c. Nuclear power plants: Nuclear generating capacity growing rapidly (from 6,000 Megawatts, or 2% of total, in 1970, to 475,000 Mw, or 40% of total, in 1990). Improved design methods being used to sustain trend toward larger nuclear plants (typically 200 Mw in 1965, 500 Mw in 1969, and 1,000 Mw in 1974). Annual capital investment in nuclear power was $3.5 billion in 1972 and 1973. (D-6)

D. ELECTRIC UTILITIES

*D-1 Combustion analysis computer programs: developed by Lewis and for Johnson . . . . used since 1970 by former space program combustion experts, KVB Engineering, Inc. (California), to design firing modifications for power plant fossil-fueled boilers. . . . reduced nitrogen oxide emissions by 40-70% in compliance with legal standards. . . . KVB has analyzed emissions from 160 large boilers, 100 small boilers and 30 ground power gas turbines . . . . over 100 large boilers modified for utilities nationwide, e.g., Southern California Edison Co., Los Angeles City Department of Water and Power, Consolidated Edison (New York), and Houston Lighting and Power Co. . . . . pollution reductions by KVB method considerably less expensive than by any known alternative; little or no added operating costs. (Contractor, TEF 463, Case No. 86009, 9/74)

D-2 Combustion analysis computer program: developed by Lewis. . . . used by Babcock and Wilcox Co. (Ohio) to modify utility boiler product designs for reduced nitrogen oxide emissions and to develop new sulfur dioxide removal system for power plant stack gases. . . . unique capability to analyze operating trends for experimental hardware, a guide in design improvements. (Personal contact/Lewis, TEF 463, Case No. 86016, 1/73)

*D-3 Apollo Guidance Computer software: developed for Johnson. . . . used by TRW Controls (Texas) to develop TRW Executive Program and other software for electric power dispatch computers. . . . provides real-time control capability in large, multi-tiered computer systems installed at General Public Utilities Corp. (Pennsylvania and New Jersey) and Arkansas Power and Light ($500,000 installation). . . . also being installed at Public Service Co. of Oklahoma and Swedish State Power Board. . . . Apollo software also used by TRW Industrial Operations (California) to provide real-time control capability in new Bonneville Power Administration (Washington) dispatch computer system ($5.2 million installation). . . . benefits cited by BPA include decreased blackouts and $400,000 annual transmission savings . . . . TRW is second largest producer of dispatch computer systems in U.S. (Contractor, TEF 465, Case No. 86005, 8/74)

D-4 Digital color television display: developed for Johnson Mission Control Center by Philco-Ford (Texas). . . . P-F developed commercial product for electric utility dispatch computer control center. . . . DCTV display installed at Cleveland Electric Illuminating Co. (Ohio), Houston Lighting and Power Co. (Texas) and Pennsylvania-New Jersey-Maryland power pool control centers. . . . product line sold to North American Rockwell Information Systems Co., NARISCO, (California). . . . installed at Philadelphia Electric Co. (Pennsylvania) as part of dispatch computer system developed by NARISCO . . . . DCTV provides operator/dispatch computer interface with greater accuracy, shorter response time, and more versatility, which decrease the chance of another major blackout. (Contractor, TEF 465, Case No. 86006, 2/73)

* Denotes transfer case related to Key Issue.

D-5 Atlas-Centaur rocket control system (mathematical model): developed for Lewis . . . . same group of experts used method to design control system for high temperature gas-cooled reactor (HTGR) at General Atomic Co. (California). . . . first commercial HTGR is 330-Mw Fort St. Vrain Plant for Public Service Company of Colorado, in operation late 1974. . . . significant advance in nuclear plant efficiency (40% versus 33% for water reactors) due to higher performance; HTGR required more sophisticated control system. (Personnel/contractor, TEF 446, Case No. 84984, 11/72)

*D-6 Fracture toughness tests (and analytic methods): developed by Lewis. . . . included in ASME Boiler and Pressure Vessel Code for nulcear power plant components. . . . used by major manufacturers to design nuclear plant equipment and steam turbines. . . . users include Westinghouse (Pennsylvania), General Electric (New York), Babcock and Wilcox (Ohio), Atomics International (California), General Atomic (California) and Combustion Engineering (Tennessee) . . . . annual capital investment in nuclear power was $3.5 billion in 1972 and 1973. . . . trend toward larger nuclear plant designs (200 Mw in 1965, 500 Mw in 1969, and 1,000 Mw in 1974). (Professional society, TEF 451, Case Nos. 85203, 85204, 85206, 85208, 85212, 86001, 1/73)

D-7 Fatigue analysis methods: developed by Lewis. . . . included in ASME Elevated Temperature Design Code. . . . used by General Electric Co. (New York) for steam turbine design, Westinghouse (Pennsylvania) for steam turbine maintenance, General Atomic Co. (California) for high temperature gas-cooled reactor design, Combustion Engineering, Inc. (Tennessee) and Babcock and Wilcox Co. (Ohio) for electric power steam generator design. . . . provides better prediction of fatigue life from high temperature test data. (Professional society, TEF 450, Case Nos. 85202, 85207, 85213, 86000, 86002, 1/72)

D-8 Apollo Program quality assurance specifications: (NPC 200-2) developed by Headquarters. . . . modified by DOD for military specs (MILQ 9858A) which in turn were largely incorporated by AEC (District of Columbia) in comprehensive quality assurance specs for nuclear plant licensing. . . . General Electric Co. (Florida) implemented Apollo specs under NASA contract, now offers Nuclear Quality Assurance Consulting Service to do same service for electric utilities with similar AEC specs. . . . four utilities and five nuclear plant contractors have used GE service on 12 nuclear plants, including Commonwealth Edison Co. (Illinois), Florida Power Co., and TVA (Tennessee) . . . . Ontario Hydro (Canada), third largest electric utility in North America, 15,000-Mw capacity, is using NASA specs to develop own QA specs for contractors. (Interagency for AEC, Contractor for GE, Professional society for OH, TEF 444, Case Nos. 84976, 87032, 2/73)

* Denotes transfer case related to Key Issue.

D-9 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by General Atomic Co. (California) for dynamic modeling of high temperature gas-cooled reactors, Westinghouse (Pennsylvania) for designing nuclear power plants that will float offshore, and Handford Engineering Development Laboratory (Washington) for fast breeder reactor design analysis. . . . provides unique capability for using computer in design analysis of large, complex structures. (Personal contact, Professional journal/COSMIC, TEF 410, Case Nos. 84977, 84981, 86003, 1/73)

D-10 Fuel cell technology: developed for Lewis and later supplied to Johnson by United Aircraft Corp., Pratt & Whitney Aircraft Div. (Connecticut). . . . used by P&W in joint R&D ventures with two utility groups to develop commercial fuel cells. . . . Team to Advance Research for Gas Energy Transformation (TARGET), including 28 major gas and gas/electric utilities, has spent over $70 million since 1967. . . . 12.5-kW cells successfully pilot tested at 20 U.S. sites. . . . second venture started in 1972; includes 9 electric utilities and the Edison Electric Institute. . . . goal is 26-Mw generating units. . . . field tests for basic 4.5-Mw cells expected to start by 1979 . . . . both ventures developing cells which convert natural gas or liquid fossil fuels to electricity with greater efficiency and less pollutants than conventional generating methods. (Contractor, TEF 448, Case No. 84992, 5/75)

Other Relevant Examples:

B-6 (gas turbine electric generators); B-23 (nuclear reactor filters); E-7 (coal mine reclamation); E-10 (coal desulfurization); G-2 (power plant siting maps); G-3, G-7 (hydroelectric plant scheduling and planning); I-10 (portable power poles); O-5 (NDT training service)

E. ENVIRONMENTAL QUALITY

Key Issues

a. Carbon monoxide pollution in urban areas: a study recently published by the Medical College of Wisconsin showed that three-fourths of those persons examined in Denver, Los Angeles, and Chicago had blood concentrations of carbon monoxide above 1.5%, the level set as harmful by federal standards. A National Academy of Sciences report estimated that in urban areas 4,000 deaths and 4 million illness-related days from work were due to auto air pollution. (E-1)

b. Vehicle emission standards and certification: New car emission standards have increased average cost of pollution control devices from $17 in 1968 to $115 in 1974 to estimated $246 for 1975 models. New vehicle certification requires vehicle emissions of hydrocarbons, carbon monoxide, and nitrogen oxides to meet EPA standards using EPA-approved testing procedures. States are developing programs for annual emission inspection of all vehicles. (E-2)

E. ENVIRONMENTAL QUALITY

*E-1 Skylab carbon monoxide monitor: developed for Ames. . . . commercialized by Andros, Inc. (California) as air pollution monitor. . . . now sold by Beckman Instruments (California). . . . unique design features allow accuracy and portability. . . . instrument certified by EPA. . . . over 30 sold @ $6,800 to air pollution agencies and companies. . . . used to measure carbon monoxide pollution in urban areas, such as the CO profile over Los Angeles. (Contractor, TEF 481, Case No. 93827, 10/73)

*E-2 Hazardous gas analyzer for Saturn rocket: developed for Marshall. . . . adapted by Chrysler Corp. (Alabama) to develop product line of vehicle exhaust analyzers. . . . over 70 large units sold @ $15,000-$50,000. . . . provides simultaneous measure of CO, CO_2 and hydrocarbons. . . . allows automated testing. . . . analyzer accepted as legal alternative standard by EPA and California for vehicle emission certification testing. . . . used by Chrysler (Michigan) for new vehicle certification (heavy duty engines) and quality control during production. . . . used by Chrysler (California) for 2% Quality Audit of new cars, a California requirement (3,000 cars/year, $600,000 test facilities). . . . also used to trouble-shoot defective vehicles, reducing labor costs at least 50%. . . . Chrysler's portable exhaust analyzer product used for state inspection by garages and car dealers. . . . over 1,000 small units sold @ $1,600. (Contractor, TEF 486, Case No. 93832, 9/74)

E-3 Filter cassette for sampling particulate pollutants: designed and produced for Lewis air pollution program in Cleveland by General Metal Works, Inc. (Ohio). . . . commercialized by contractor. . . . $25 cassette widely sold for pollution monitoring stations. . . . considered by pollution experts to be best cassette on market. . . . prevents sample contamination during transport to and from monitoring stations. (Contractor, TEF 493, Case No. 99658, 6/74)

E-4 Satellite telemetry systems: developed for Goddard by General Electric Co. (Pennsylvania) for Nimbus and ERTS-1. . . . used by GE to develop state-wide computerized air pollution monitoring network (COPAMS) for Pennsylvania . . . . 32 stations to implement air quality laws. (Contractor, TEF 483, Case No. 96532, 2/74)

E-5 Weather satellite data: program managed by Goddard. . . . used by National Weather Service (Maryland) to forecast wind conditions. . . . forecasting used by state air pollution agencies (Colorado and others) for air stagnation maps and air pollution dispersal conditions. . . . dispersal prediction crucial for implementing pollution control sequence (advisory, alert, warning, emergency). (Interagency, TEF 26, 194, Case Nos. 78001, 96526, 10/73)

E-6 ERTS-1 imagery: program under Goddard supervision. . . . imagery used by scientists at University of Vermont to identify and map major pollution plume in Lake Champlain caused by paper mill. . . . partial basis for legal action by State of Vermont against paper mill and State of New York. . . . ERTS imagery and interpretation of imagery accepted as legal evidence in case after review by Supreme Court-appointed master. . . . one of first pollution cases involving state vs. state accepted by Supreme Court. (Contractor, TEF 500, Case No. 101911, 9/74)

* Denotes transfer case related to Key Issue.

E-7 Aircraft remote sensing program and imagery: program by Johnson. . . . infrared photographic imagery of Midwest used in 1971 by Purdue University (Indiana) and U.S. Department of Agricultrue to analyze spread of corn blight. . . . Indiana portion of imagery used by Earth Satellite Corp. (District of Columbia) to map and measure coal mine refuse piles. . . . maps now used by Indiana legislature in preparing legislation on reclamation of mine refuse sites. . . . 200 sites larger than 2 acres each were identified and reclamation cost estimate exceeded $14 million. (Contractor, TEF 199, Case No. 101912, 9/74)

E-8 Remote sensor for air pollutants: operational prototype developed for Johnson. . . . correlation spectrometer sold by Barringer Research, Ltd. (Canada). . . . over 40 sold @ $23,000. . . . unique air pollutant measuring capability. . . . measured NO_2 profiles over Los Angeles and San Francisco, SO_2 profile over Chicago. . . . also used by air pollution agencies in U.S., Canada, Australia, Japan, France, Spain. (Contractor, TEF 482, Case No. 95608, 8/73)

E-9 Computer models for Apollo Program: developed for Johnson. . . . used by TRW Systems (California) to develop more than 30 air and water quality models . . . . provided technical basis for implementing pollution laws in Alaska, California, D.C., Ohio, South Carolina, Vermont. (Contractor, TEF 487, Case No. 96531, 1/74)

E-10 Lunar Module rocket engine test facility: developed for Johnson. . . . used by TRW Systems (California) to develop inexpensive coal desulfurization process. . . . EPA funding at $1.5 million for research and pilot plant design . . . . process could eliminate need for expensive stack gas removal equipment for electric utilities. . . . SO_2 pollution control a critical financial problem for coal-fired power plants. (Contractor, TEF 488, Case No. 96530, 9/74)

E-11 Computerized image enhancement: developed by Jet Propulsion Laboratory (California) to process digitized image transmissions from unmanned spacecraft (e.g., Ranger and Mariner). . . . used by JPL in current program to develop computer processing of water quality data from ERTS-1 multispectral digitized imagery. . . . joint funding by TUO and EPA (Oregon) to obtain cheaper, more efficient method for classifying quality of inland lakes in National Eutrophication Survey (NES). . . . good correlation between JPL results and EPA's water sampling data. . . . EPA initiated NES in 1972 to determine lake deterioration caused by phosphorus materials in sewage plant effluent. (Contractor/TUO-Applications Project, TEF 520, Case No. 104142, 10/74)

E-12 Manufacturing contamination prevention handbook: compiled for Marshall . . . . used by Carrier, Carlyle Compressor Co. (New York), to develop in-house pollution control system for process machinery coolants. . . . system reduced pollution emitted into city sewer system, improving employee/citizen health conditions. . . . system approved by OSHA. (TB/TSP, TEF 544, Case No. 86150, 3/75)

E-13 Quartz crystal microbalance contamination monitor: developed for Marshall Skylab contractor by Celesco Industries, Inc. (California). . . . led to development of real-time pollution monitor product. . . . highly reliable, operates under wide range of conditions, reveals variety of contaminant sources. . . . numerous units sold @ $5,000-$20,000 each. . . . State of New Mexico environmental control agencies use product for particulate measurement. (Subcontractor, TEF 567, Case No. 109335, 5/75)

E-14 Mass flowmeters for low gas flow: developed to meet specifications of Johnson Apollo subcontractor by Tylan Corp. (California). . . . used by Tylan to develop product for calibrating air pollution monitoring instruments. . . . provides the extremely accurate measure of gas sample volume necessary for analysis of pollutant concentration. (Subcontractor specifications, TEF 563, Case No. 109332, 5/75)

Other Relevant Examples:

B-13 (noise pollution, fan noise reduction method); D-1 and D-2 (air pollution control for power plants); D-8 (nuclear safety); G-1 (new sewage treatment method); G-2, G-3, G-5 and G-6 (water quality and supply data); H-1 (reduced offshore oil pollution); H-7, H-10 and H-11 (reduced air pollution for refinery, gasoline bulk stations and engine fuels); K-2, K-4 and K-5 (reduced automobile emissions)

F. FOOD PRODUCTION AND PROCESSING

Key Issues

a. Productivity: over last century, mechanization made possible a ten-fold decrease in farm workers needed to feed U.S. (47% of work force in 1870, 4% in 1970). Farm crop output per man-hour increasing at annual 10% (versus 3% national average); a major factor is improved equipment. In 1960, 40% of tractors were 60 hp. or less; in 1972, two major producers (Deere and Allis-Chalmers) introduced new models over 150 hp. which increase productivity 10-20% by pulling standard implements faster or pulling larger implements. (F-2)

b. Food products merchandising: continuing developments in merchandising--rigorous quality assurance, improved inspection programs, and open-dating of packaged, perishable food goods--have permitted the $119 billion U.S. food industry (meat packing $26 billion) to provide quality food for consumers. Average U.S. family spent 15.9% of its after-tax income on food in 1973. (F-8)

F. FOOD PRODUCTION AND PROCESSING

F-1 Weather satellite imagery and ground receiver: developed for Goddard. . . . used by National Weather Service (Maryland) as a major input to preparing daily fishery advisory charts for eastern Pacific. . . . charts transmitted by National Marine Fisheries Service (California) to radio facsimile receivers on 70 U.S. tuna boats in Pacific; represents 50% of U.S. tropical tuna fleet . . . . information reduces time and fuel costs for locating tuna, helps in avoiding adverse weather. . . . annual Pacific tuna catch worth over $75 million; provides 90% of tuna canned in U.S. (20% of U.S. fish consumption is canned tuna). (Interagency, TEF 194, Case No. 78002, 3/75)

*F-2 Fracture toughness tests: developed by Lewis. . . . used at Deere and Co. (Illinois) to improve safety and service life of products (snowmobiles, farm tractors and implements). . . . reduced fracture failure of snowmobile drive trains, tractor roll-over protection systems (ROPS). . . . ROPS required by OSHA, Deere selected steel on basis of fracture tests. . . . 20% of research department effort on these applications. . . . Deere introduced new 150 hp. tractor in 1972, increased productivity 10% by pulling large implements or same implements faster. . . . implement service life not decreased, partly due to improved fracture toughness matching higher performance (e.g., plow striking rock could have caused brittle fracture). . . . Deere annual sales over $1 billion, about 25% of farm machinery market. (Professional society, TEF 451, Case No. 101903, 8/74)

F-3 Precipitation-hardened steel alloy: developed for Johnson (Apollo Command Module) by Armco Steel. . . . Armco alloy used by Hopper, Inc. (California) in fabricating Ram-Jet, wind machine for frost protection in noncitrus orchards (apples, almonds, etc.). . . . @ $7,000. . . . several hundred operating in Washington, Oregon and California. (Contractor, TEF 223, Case No. 42553, 8/74)

F-4 Contamination control handbook: compiled for Marshall. . . . used at USDA Research Center (Louisiana) for training employees and research. . . . recommended by USDA to food processing firms with contamination problems. . . . one research application was developing a process for converting cottonseed pulp to high protein (67%) flour for human consumption. . . . due to contamination problem, pulp from cottonseed oil production mainly used for cheap animal feed. . . . new process solves problem and one cottonseed mill already producing the more profitable flour. (TB/TSP, TEF 262, Case No. 31762, 8/74)

F-5 Clean room technology: developed for Johnson by Pillsbury Co. (Minnesota) . . . . Pillsbury originally installed clean rooms, conducted employee training programs, and compiled a contamination control management practices manual for astronaut food production facility. . . . technology applied in all new food processing facilities at Pillsbury, clean rooms are installed in some older facilities, and all employees receive contamination hazards training . . . . improved product quality and reduced product recalls due to contamination. . . . managment manual (720 pages) is publicly available and used by FDA (District of Columbia) to train federal food inspectors. (Contractor, TEF 503, Case No. 101910, 8/74)

* Denotes transfer case related to Key Issue.

F-6 Microbiological handbook: compiled for Marshall. . . . used by Kraftco Corp. (Illinois) as training manual for sanitary techniques in food processing plants and in research. . . . used by USDA scientists (Missouri) in development of improved milk processsing procedures and equipment now used in dairy industry. . . . valuable reference in both cases. (TB/TSP, TEF 402, Case Nos. 51578, 51786, 9/74)

F-7 Nondestructive spot test procedure: compiled by Langley. . . . used by Kraftco Corp. (Illinois) for alloy identification when analyzing chemical reactions for food, atmosphere, and stainless steel processing equipment combinations. . . . time and money saved when reaction problem occurs and must be eliminated to avoid food contamination. (TB/TSP, TEF 378, Case No. 47744, 8/74)

*F-8 Electronic strain gage: invented by founder of BLH Electronics. . . . improved and standardized by BLH for space program which was the first major market . . . . used by field centers (Goddard, Lewis and Marshall) and contractors in most rocket engine R&D projects and space vehicles such as the surveyor lunar lander. . . . commercial markets developed by BLH for standardized products. . . . product used by Armour and Co. (Illinois) in Armour Tenderometer since 1969. . . . unique capability to test hanging carcass and accurately predict meat tenderness after cooking, not possible previously. . . . Armour selects and guarantees all TesTender beef with instrument. . . . amount of premium-priced TesTender beef sold annually is tens of millions of pounds . . . . Armour was awarded 1973 Food Technology Industrial Achievement Award for Tenderometer, a major innovation in beef merchandising. . . . cattle growers using the instrument data for selective breeding programs. (Customer/subcontractor, TEF 505, Case No. 101898, 103418, 10/74)

F-9 Compressed/freeze-dried food: developed for Johnson. . . . marketed by Innovative Foods (California) as compact emergency food rations. . . . used by hunters, backpackers, etc. . . . sales expected to reach approximately $1 million within a year. (Personal contact/contractor, TEF 502, Case No. 101896, 8/74)

F-10 Eutectic salts for low temperature batteries: developed for Goddard by Artech Corp. (Virginia). . . . used by Artech to develop Irreversible Warmup Indicator. . . . shows, by color change, whether frozen foods have defrosted during transportation or storage. . . . 3 million sold, total sales $100,000. (Contractor, TEF 504, Case No. 101897, 8/74)

F-11 Cooling system for Gemini space suits: developed for Johnson by Garrett Corp. (California). . . . adapted by Garrett to develop galley refrigeration system for commercial aircraft. . . . used by Western Airlines. . . . total sales about $500,000, 50 units installed. (Contractor, TEF 228, Case No. 430, 8/74)

*Denotes transfer case related to Key Issue.

F-12 Computer programs for ERTS-1 data analysis: developed for Johnson by Lockheed Corp. at request of Texas Water Rights Commission. . . . used by Texas Water Development Board to develop monitoring program for playa lakes (short-lived, caused by rainstorms) in Texas High Plains region. . . . computer analysis of LANDSAT data will permit production, every 30 to 45 days, of maps which show size and location of lakes. . . . data from repetitive monitoring very important for planned effort to utilize playa lakes for farm irrigation and recharge of rapidly depleting Ogallala Aquifer which is vital to High Plains agriculture. . . . preliminary results indicate computer analyzed satellite data much more cost effective than other monitoring methods. (Personal contact/Johnson, TEF 513, Case No. 101895, 5/75)

Other Relevant Examples:

A-9 (production equipment lubrication); G-6 (flood forecasting); K-3 (farm tractor design)

G. GOVERNMENT

Key Issues

a. Sewage treatment facilities: EPA's Needs Survey for 1973 set the costs for new water treatment equipment between 1973 and 1990 at $61.7 billion to satisfy the water quality requirements in the Water Pollution Control Act of 1972. This represents a three-fold increase over the 1971 cost estimate ($18.1 billion) which was based on previous, less stringent water quality standards. Two major cost factors in the new projection are secondary treatment facilities ($17.1 billion) and new sewer systems ($24.5 billion). Costs to be shared by federal (75%) and local governments (25%). (G-1)

b. Natural resource management: Revenues from natural resources managed by all levels of government were $3.67 billion in 1971 ($3.33 billion from federal resource leases, water projects, etc.). All government expenditures for natural resources and the environment were $11 billion in 1965 (includes $1.73 billion by state/local) and $13.7 billion in 1971 (includes $3.67 billion by state/local), with about 6% for capital outlays. These expenditures covered such areas as land, watershed, and wildlife management, as well as pollution and flood control. Federal aid to state and local governments for resource management increased rapidly from $300 million in 1965 to $1.33 billion in 1973. There is a critical need at all government levels for better resource information at lower cost to support the government management efforts required by recent environmental legislation. (G-2)

G. GOVERNMENT

*G-1 Pyrolytic synthesis of activated carbon: developed for Headquarters by Jet Propulsion Laboratory (California) to prepare rocket insulation. . . . used by JPL, under NASA contract, to develop novel sewage secondary treatment pilot plant. . . . 10,000-gal./day plant converts sewage to activated carbon by pyrolysis. . . . carbon then used to remove organics from primary treatment water, to increase raw sewage settling rates by 100-fold, and to fuel pyrolysis process. . . . minimizes solid waste disposal, eliminates odors, and removes most heavy metal pollutants from waste. . . . effluent will satisfy 1983 water quality requirement set by Water Pollution Control Act of 1972 at a lower total cost than less satisfactory secondary treatments currently used. . . . pilot plant now operated by Orange County Sanitation District (California), with NASA and county funds ($200,000), to develop scale-up design data. . . . county is developing one million-gal./day prototype plant on cost-sharing basis (county 12.5%, state 12.5%, EPA 75% of $3.4 million). . . . will determine feasibility and design criteria for combining new process with primary treatment plants nationwide. . . . EPA estimates that $17.1 billion will be spent on new secondary treatment plants by 1990. (Contractor, Client/contractor, TEF 516, Case Nos. 103403, 103404, 10/74)

*G-2 ERTS-1 imagery: program under supervision of Goddard. . . . used by Ohio to construct maps utilized for power plant siting, forest inventory, and pollution and resources management of Lake Erie shoreline. . . . Georgia has a continuing program to utilize ERTS-1 imagery; applications have included a state map (effort took one man-week to prepare; comparable map using ground survey estimated @ over $1 million and several man-years) used for farm pond and earthfill dam inventories; also being used to map coastal marshland for a comprehensive marshland protection program. . . . being used in Utah for map preparation, a hydrologic survey, and wild life assessment to develop state management policies for the Great Salt Lake area; also used to prepare a map of Tooele County for land use planning, with current application in zoning and identifying new recreation areas. (Contact/federal agency, Contractor, TEF 500, Case Nos. 101904, 101913, 101925, 101928, 9/74)

G-3 ERTS-1 data collection system: developed by Goddard. . . . used by U.S. Geological Survey (Florida) to telemeter hydrologic data from 20 key remote Data Collection Platforms in southern Florida. . . . only feasible way to obtain data consistantly on a near real-time (less than 1 hr.) basis. . . . data used in water management for 1,500 miles of canals and hundreds of control facilities to supply the water needs of southern urban areas, Everglades, wildlife preserves. . . . rapid monitoring critical for flood control (hurricanes) and maintaining water quality during storm water runoff. . . . USGS ordered 35 more DCP's for southern Florida network. . . . used by Department of the Environment (Canada) to telemeter river discharge data from remote areas subject to intense cold. . . . high quality data obtained at low annual maintenance and operating costs (less than $100/station, cheaper than radio by a factor greater than 10). . . . data used for flow and flood forecasting, design of future hydroelectric power plants, pollution control. . . . Dept. of Environment quadrupling (9 to 40) number of DCP's. (Interagency, TEF 509, Case No. 101930, 9/74)

* Denotes transfer case related to Key Issue.

G-4 Computer programs for ERTS-1 data analysis: developed for Johnson by Lockheed Corp. at request of Texas Water Rights Commission. . . . being used by Texas Water Development Board under contract to U.S. Army Corps of Engineers, Nashville District (Tennessee), to analyze ERTS-1 imagery for verification of dam inventory in Tennessee. . . . accurately identifies water bodies over 10 acres . . . . reduces verification cost by factor of 10. . . . may be used to verify inventories in other states after Tennessee trial. . . . dam inventory is part of federally funded Program of Inspection of Dams authorized by Congress in response to dam failures at Buffalo Creek, West Virginia and Rapid City, South Dakota. . . . hundreds died in these disasters. (Interagency, TEF 513, Case No. 101905, 9/74)

G-5 Skylab photography: program under supervision of Johnson. . . . used in NASA-funded EREP experiment by U.S. Geological Survey (Florida) with computer processing to construct detailed hydrologic map of Florida's Green Swamp area. . . . swamp is headwaters for 4 rivers which are critical for water needs of central Florida. . . . map shows well-, moderately and poorly drained land in entire swamp (8,000 sq. miles). . . . key factor in facilitating amicable out-of-court settlement of multimillion dollar suit between State of Florida and land developers by showing which areas could be developed without damaging water supplies . . . . Florida Dept. of Natural Resources providing funds to publish the map for land use management. (Interagency, TEF 508, Case No. 101929, 9/74)

G-6 Slidell computer complex: established by Marshall for production management and checkout of Saturn rocket. . . . a major computer facility in south central U.S. . . . since 1971, also used by National Weather Service to forecast flow and stages of all major rivers in five state area (Mo., Ark., Tenn., La., Miss.) . . . . large, third generation computer essential for digital simulation model forecasting (first use of this technique by NWS) which provides 72-hour forecasts accurate within 0.3 ft. . . . forecasts important for flood control; also used by farmers and shippers. . . . other agencies using computer facility include Corps of Engineers (Red River sedimentation analysis), U.S. Geological Survey (environmental studies), National Park Service (user study of Great Smoky Mountains National Park). (Interagency, TEF 506, Case No. 101926, 9/74)

G-7 Saturn I/IB Systems Development Breadboard Facility: installed and operated for Marshall by Chrysler Corp. (Alabama). . . . process control technology used to design memory system for new post office automated parcel sorting equipment . . . . reduced cost of parcel sorting, high speed and reliability. . . . Chrysler units worth about $500,000 already installed at 3 post offices (Binghamton, N.Y., Greensboro, N.C. and Chicago, Ill.). . . . 2 more on order for California and Postal Service planning additional installations. . . . data acquisition technology used in automated system for real-time collection and processing of hydrometeorological data from Columbia River Basin for Bonneville Power Administration. . . . 43 data gathering stations linked by microwave and VHF radio to master station in Portland. . . . system used for flood control, management of water and forest resources, and providing data from computing hydroelectric plant generating schedules. (Contractor, Customer/contractor, TEF 507, Case Nos. 101923, 103405, 9/74)

G-8 Systems analysis and computer modeling: developed for Headquarters by Jet Propulsion Laboratory (California). . . . used by JPL, under contract to TUO and Los Angeles Comprehensive Health Planning Council, to develop local health care planning computer model. . . . integrates demographic, health, health services and other data. . . . provides better projection of hospital bed requirements than HEW planning model which is now used nationwide by states and local councils to allocate hospital construction funds from HEW . . . . successful application by JPL of model within LA council area. . . . California evaluating model for statewide use in place of HEW model. (Contractor, TEF 514, Case No. 103401, 9/74)

G-9 California Four Cities Program: funded by NASA and NSF (since 1971) and managed by Jet Propulsion Laboratory (California) to transfer aerospace-generated technology to local governments. . . . four aerospace companies (Northrop Corp., Science Applications, Inc., Aerojet-General Corp., and Lockheed Missiles and Space Co.) are paired with four cities (Anaheim, Fresno, Pasadena, and San Jose). . . . each company provides its paired city with a Science and Technology Advisor and technical support. . . . eleven formal projects undertaken, as well as informal consultation and advising. . . . program has cuased city management consideration or use of new devices and methods, including public safety hardware, planning software, system management and integration approaches, and variety of management technique improvements. . . . ongoing or completed management applications include cable television franchise negotiations, municipal waste, vehicle replacement scheduling, and computerized Municipal Information System. . . . cities achieving considerable cost savings and operational improvements, with quantified savings from only two projects estimated at more than $600,000. . . . program currently being extended to additional cities, with coordination through the League of California Cities. (Contractor, TEF 512, Case No. 101915, 9/74)

G-10 Apollo Management Control Room: designed for Kennedy by Midwest Research Institute (Missouri). . . . used by MRI as a model to design a management control room for Kansas City officials overseeing construction of the $200 million city airport. . . . project so successful, design of 3 additional control centers funded by city and other local government agencies: Jackson County (Missouri) Courthouse, Alcohol Safety Action Project, and City Council Goals and Progress Center. (Contractor, TEF 510, Case No. 101924, 9/74)

G-11 Space simulation chamber: developed and maintained for Johnson by McDonnell Douglas Corp. (Missouri) for Mercury and Gemini programs. . . . used by MDC to restore water damaged records with heating/freeze-drying process. . . . restored more than 20% of 20 million records destroyed or damaged by 1973 fire at Military Personnel Records Center (Missouri). . . . large cost savings by reducing the number of records that must be reconstructed from other sources . . . . restoration was not possible without chamber. . . . Center normally uses records to process 9,000 requests daily concerning retirement benefits, entitlements, etc. . . . MDC received $400,000 for military records restoration and $200,000 from 10 subsequent restoration contracts. (Contractor, TEF 511, Case No. 101914, 9/74)

G-12 Nondestructive spot test procedure: compiled by Langley. . . . frequently used by Occupational Health Dept., State of New York Labor Dept., to perform screening tests on samples from companies during investigations of health or safety hazards. . . . provides rapid, inexpensive pretest before more detailed test procedures. . . . investigation results are basis for recommending changes to companies and possible legal action to force elimination of hazards. (TB/TSP, TEF 378, Case No. 44538, 8/74)

G-13 Fireman's breathing apparatus: developed by Johnson, in cooperation with firefighting community, using extravehicular life support system technology . . . . funded by TUO. . . . Martin Marietta Corp. (Colorado) and Structural Composites Industries (California) contracted to build lightweight pressure vessels. . . . A-T-O, Inc., Scott Aviation Div. (New York), contracted to build other system components. . . . resulting unit includes: reduced weight/increased duration, simplified harness, improved helmet, mask, and air depletion warning device. . . . field evaluation of new system taking place in Los Angeles, Houston, and New York City. . . . Scott to make units commercially available in late 1975. (TUO-Applications Engineering, TEF 519, Case Nos. 107781, 107783, 11/74)

G-14 Systems management techniques: compiled by Marshall. . . . used by E-Systems, Inc. (Texas) in management of large systems project for Defense Department . . . . application of documentation control and computerized task scheduling techniques allowed completion of project on time. . . company estimated benefits to be worth $800,000. (TB/TSP, TEF 494, Case No. 99834, 3/75)

G-15 Risk-management system: developed by Kennedy for rocket fuel storage and handling. . . . used by Kennedy in TUO-funded project to provide New York City Fire Department with management system for liquefied natural gas (LNG) storage facilities. . . . public safety increased through better identification, analysis, and control of hazards associated with LNG facilities in the city. . . . project undertaken after 1973 fire at large LNG tank on Staten Island killed 40 people. (TUO-Applications Engineering, TEF 549, Case No. 107737, 1/75)

G-16 Flammability tests of home furnishings: conducted for TUO by Battelle Columbus Laboratories to compare performance of aerospace materials with conventional furnishing materials in full-scale bedroom fires. . . . test results from report used in government programs to improve fire safety . . . . used by U.S. Department of Agriculture's Forest Products Laboratory (Wisconsin) to design better fire tests for wood structure test program. . . . used by National Bureau of Standards (Maryland) to develop simplified model for estimating quantities of combustion gases produced during a fire and to educate fire technology researchers on fire behavior . . . . used by Columbus Fire Department (Ohio) to obtain data on combustion gases and improve safety for firefighters. . . . also used by New York City Fire Department to help implement city ordinance on fire safety of commercial high-rise buildings; provides input to department recommendations for interior furnishings. (TUO conference, Contact/TUO and contractor, TEF 539, Case Nos. 107034, 107040, 107041, 107047, 107048, 1/75)

G-17 Properties of air in microwave components: developed for Marshall. . . . used by U.S. Navy's Puget Sound Naval Shipyard (Washington) to improve dry air systems for shipboard electronics and to educate new electronic engineers . . . . to date, dry air systems installed on about 10 ships; reduce ionization in radar waveguides, coaxial cables and other electronic components. (TB/TSP, TEF 542, Case No. 98756, 2/75)

G-18 Linear shaped explosive charge: developed for Johnson by Explosive Technology (California) to separate stages of launch vehicles. . . . commercialized by ET as Jet-Axe. . . . used by firefighters to blast holes in burning buildings for forcible entry or ventilation. . . . annual sales 500 units @ $85-$150. (Contractor, TEF 559, Case No. 109329, 5/75)

Other Relevant Examples:

B-15 (military receivers); C-2 (fire fighting equipment); C-7 (U.S. Coast Guard life raft); D-3 (Bonneville Power Administration control system); D-8 (AEC licensing regulations); E-4, E-5, E-8 and E-9 (air quality agencies); E-6 (state vs. state case); E-7 (state legislature); E-11 (EPA National Eutrophication Survey); F-1 (National Marine Fisheries Service); F-4 and F-6 (USDA food processing); F-5 (FDA training manual); H-1 (USGS regulations); I-3 (HUD Operation Breakthrough Program); I-6 (New York City sewage system); I-7 (U.S. Army Corps of Engineers dam projects); I-10 (FAA radar beacon siting); J-1, J-3 and J-4 (police departments); J-2 (LEAA information system); K-1 (state highway departments); K-2 (DOT Urban Systems Program/ local traffic departments); L-6 (police and fire departments) L-7 (High-Speed Ground Test Center); M-2 (military aircraft); M-6 (FAA fire safety standards); M-7 (airport runway grooving)

H. PETROLEUM AND GAS

Key Issues

a. Offshore oil production: 176 billion bbl. of oil and 248 trillion cu. ft. of gas have been discovered on worldwide continental shelves, with vast areas still unexplored. Offshore oil production in 1970 was 1.6 million bbl./day for U.S. and 7 million bbl./day worldwide; U.S. production remained the same in 1973, and world production increased to 10 million bbl./day. Pollution from offshore production became major environmental issue in 1969 with Exxon Co. well blow-out in Santa Barbara Channel off California. U.S. offshore industry and regulatory agency, U.S. Geological Survey, improving safety and antipollution regulations in response to public pressure. U.S. leasing was accelerated in 1973. (H-1)

b. New gas supplies: In 1970, U.S. consumed 23.4 trillion cu. ft. of gas; approximately 95% of this was natural gas produced in U.S. Gas is the premium fossil fuel since it is easy to transport, clean burning and almost pollution free. If supplies were available, 1980 consumption would be 35.8 trillion cu. ft. Estimated that only 24 trillion cu. ft. of natural gas will be produced in 1980, shortfall of 11.8 trillion cu. ft. Synthetic gas production facilities and LNG import terminals are being developed rapidly to improve gas supplies in U.S. Additional 1980 gas supplies projected at 2.1 trillion cu. ft. syngas and 1 trillion cu. ft. LNG imports. U.S. has 2 operating LNG import terminals, 5 under construction and 6 more planned. (H-2)

H. PETROLEUM AND GAS

*H-1 Reliability and quality assurance methods: developed by Marshall. . . . used by Marshall, under contract to U.S. Geological Survey (District of Columbia and Louisiana), for 1971 study of functional reliability for safety and anti-pollution equipment on offshore oil/gas production and drilling platforms . . . . basis for improved assurance by federal government and industry that offshore oil and gas will be produced safely and with minimal pollution. . . . over 4,000 copies of report distributed to offshore industry worldwide by USGS . . . . USGS regulates all offshore operators on U.S. Outer Continental Shelf, including 1,800 drilling and production platforms in Gulf of Mexico. . . . new Recommended Practices issued by American Petroleum Institute (Texas) for subsurface safety valves and surface safety systems based on Marshall recommendations. . . . will be adopted by industry and included in USGS regulations . . . . will require licensing of equipment manufacturers in 1975. . . . additional API RP's based on Marshall study being prepared. . . . Offshore Operators Committee (Louisiana) designed computerized, industry-wide failure reporting system based on Marshall recommendation, and USGS is reviewing system before actual development and implementation. . . . Exxon Co. (Texas) and other offshore companies made equipment and operating changes to improve safety and reduce pollution hazards based on the study. (Interagency for USGS, Contact/USGS for API, Offshore Operators Committee and Exxon, TEF 484, Case Nos. 93829, 93830, 93831, 8/74)

*H-2 Cryogenic transfer system cooldown: data and analytic methods developed for Space Nuclear Propulsion Office and Lewis (NERVA Engine Program). . . . used by Chicago Bridge and Iron Co. (Illinois) to design piping systems at most large LNG import terminals in U.S. . . . cooldown rate of warm pipes at start of flow is a critical design parameter. . . . provided major input to CBI design of $7 million ship-to-shore LNG transfer system at Distrigas Corp. (Massachusetts) import terminal. . . . first (1971) major LNG import facility in U.S. (over 3 billion cu. ft. storage capacity). . . . also used by CBI to design ship-to-shore piping for Algonquin LNG, Inc. (Rhode Island, 6 billion cu. ft. storage in 1973), Columbia LNG Corp. and Consolidated System LNG Co. (Maryland, 5 billion cu. ft. storage in 1976). . . . U.S. annual LNG imports were 2 billion cu. ft. in 1971 and projected to be 2 trillion cu. ft. in 1980. (NBS Cryogenic Data Center, TEF 364, Case No. 50868, 8/74)

H-3 Insulation technology for Saturn rocket: developed for Marshall by Rockwell International Corp. (California). . . . RI licensed polyurethane insulation technology to Wanner-Isofi Co. (France) for worldwide LNG storage installations and NHK Spring Co. (Japan) for LNG tankers. . . . NHK is major corporation diversifying into shipbuilding. . . . RI conducts tests and provides consulting for licensees. . . . U.S. Coast Guard completing tests for RI prototype WET WALL Insulation System design for LNG tankers. . . . major development program for advanced marine insulation system. . . . expected advantages are signficantly lower capital and operating costs, increased volumetric efficiency and improved maintainability. . . . probable license or joint venture with U.S. shipbuilder after Coast Guard approval which is required for designs used in hazardous cargo tankers. (Contractor, TEF 361, Case No. 50221, 9/74)

* Denotes transfer case related to Key Issue.

H-4 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (Texas). . . . used by TRW Controls (Texas) to develop software and interface equipment for computerized control systems for oil field production, oil and gas pipelines. . . . major international supplier of such systems, over 3 dozen major oil and gas company customers. . . . provides "real-time" monitoring and control from central station. . . . high-speed data transmission over voice grade circuits between central station and remote terminals is innovation in supervisory control systems. . . . computer systems replacing intermediate-level automation. . . . field production benefits through reduced operating cost and increased production. . . . Exxon Co. (Texas) has computer production control (mostly TRW) in 20 major U.S. fields (200,000 barrels oil and 850 million cu. ft. gas, daily) and estimates 1-2% production benefit . . . . other customers include Continental Oil Co. (Louisiana and California), Getty Oil Co. (Texas), Imperial Oil, Ltd. (Canada), Mobil Oil Corp. (Oklahoma, California, Louisiana, Pennsylvania), National Iranian Oil Co. (Iran), Shell Oil Co. (Louisiana, Venezuela), and MAPCO, Inc. (Oklahoma). (Contractor, TEF 465, Case No. 86005, 8/74)

H-5 Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. (Texas). . . . used by SCI in remote data acquisition and control systems product line. . . . systems installed on oil and gas pipelines and oil field production equipment. . . . provides better centralized monitoring and control, with less manpower. . . . 50 installations worldwide, 30 in U.S. (Contractor, TEF 119, Case No. 4793, 9/74)

H-6 Heat pipe applications: developed for Marshall, Langley, and Ames by McDonnell Douglas Corp. (Washington) for Skylab, shuttle and unmanned satellites. . . . commercial heat pipe products developed by MDC include Cryo-Anchor soil stabilizers to prevent thawing of permafrost under structures in far north. . . . eliminates serious foundation stability problem. . . . MDC received $13 million contract from Alyeska Pipeline Service Co. (Alaska) to supply over 100,000 Cryo-Anchors for $5 billion Alaskan pipeline. . . . will be installed around pipe supports for 390-mile elevated portion of 800-mile pipeline. . . . Cryo-Anchors are 2" or 3" in diameter and range in length from 30 to 60 ft. (Contractor, TEF 197, Case No. 86008, 8/74)

H-7 Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed. . . . product used for maintenance inspections at petrochemical plants and refineries by Allied Chemical Corp. and American Oil Co. (Texas). . . . Amoco remotely detects weak links, leaks, and off-specification equipment temperatures to determine maintenance problems. . . . improved plant efficiency and reduced pollution. . . . widespread interest in scanner by oil refineries caused by Amoco success. (Customer/contractor, TEF 398, Case No. 70001, 8/74)

H-8 Hot tapping method for pipes: developed for Johnson. . . . included in maintenance manuals used at all American Oil Co. (Indiana) refineries. . . . Amoco fabricated related equipment. . . . previously, pipe or valve leaks required up to 8 people and either partial shutdown or elaborate safety procedures . . . . new method done by one or two people in half the time, with no shutdown and little fire hazard. . . . refinery may have about six serious leaks annually. (Trade journal/TSP, TEF 460, Case No. 75018, 9/74)

H-9 Nondestructive testing training manuals: developed for Marshall. . . . manuals published by contractor and distributed by American Society for Nondestructive Testing. . . . used by Mobil Oil Corp. (New Jersey) to train new employees in maintenance inspection procedures for refineries. . . . improved training and saved time in preparing instructional materials. . . . Mobil has 10 refineries in U.S. (Professional society/contractor, TEF 14, Case No. 53789, 9/74)

H-10 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Edwards Engineering Corp. (New Jersey) to select special refrigeration oil and vendor. . . . solved major lubrication problem in using off-shelf compressor for very low temperature condenser component in new Edwards product and reduced product cost. . . . unique product automatically recovers gasoline vapor at bulk distribution stations, in compliance with air pollution standards, and conserves gasoline. . . . @ $125,000, three installed and 40 on order. . . . very rapid market growth expected to continue. . . . all major oil companies have ordered at least one. . . . payback time to customer is 2-3 years. (Trade journal/TSP, TEF 497, Case No. 97902, 9/74)

H-11 Combustion analysis computer program: developed by Lewis. . . . used by Phillips Petroleum Co. (Oklahoma) to generate chemical equilibrium composition tables for all combustion research projects. . . . saved 3 professional man-years for program development and additional time for each application . . . . applied to reduce air pollution from fuel products during car engine combustion, from in-house incinerators, and from in-house burning of waste gases. (Lewis conference, TEF 463, Case No. 93825, 12/72)

H-12 Systems safety technology (and other technology related to pipeline safety): developed by several NASA field centers. . . . Regional Dissemination Center provided information to Mechanics Research, Inc. (California). . . . used to prepare proposal for the U.S. Dept. of the Interior (District of Columbia) for Alaskan pipeline safety project. . . . $18 million contract awarded in 1974. . . . information extremely important to Mechanics Research, estimated value over $100,000. (RDC-WESRAC, TUC case, 9/74)

H-13 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Shell Oil Co. (Texas) in converting approximately 500 programs for new computer. . . . reduced conversion time and saved $200 in operating costs. . . . used by Mobil Oil Corp. (Texas) in converting 4 programs for new computer. . . . saved $2,000 in operating costs. (Personal contact/TSP, Trade journal/TSP, TEF 527, Case Nos. 102812, 103812, 2/75)

Other Relevant Examples:

B-10 (LNG tankers); B-14 (petrochemical production); B-23 (blowout valve system); D-10 (fuel cells); G-15 and I-6 (LNG storage facilities)

I. CONSTRUCTION

Key Issue

Construction project management: total new construction in 1973 was $130 billion, including $53 billion for residential buildings, $26 billion for nonresidential buildings, and $14.9 billion for public utilities. Material and equipment supply bottlenecks are increasing, which adds to the normal scheduling problems and costly delays. 1965 survey of construction industry indicated a widespread opinion that the Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) would soon become necessary for success in construction contracting. 1972 construction industry survey revealed that only 14% of respondents were successful in applying these advanced management techniques in spite of the widespread interest. Two major obstacles were psychological factors and the cost, in time and money, for generating the necessary network graphics. Computerized methods to use PERT conveniently and cheaply eliminate these obstacles, and applications have been increasing since 1972. (I-1)

I. CONSTRUCTION

*I-1 NASA Pert computer program (Program Evaluation and Review Technique): developed by Marshall. . . . used by Systonetics, Inc. (California) as principal part of computer service for project scheduling in construction and other industries. . . . program widely used by customers; also available from other service companies and used in-house by some construction firms. . . . since there is no charge for NASA PERT, each user saves about $500/month compared to alternative software available commercially. . . . Systonetics combined NASA program with in-house program, EZPERT, that automatically generates graphic output. . . . significant additional savings from combined programs due to automated output of network activity graphics ($.32 @ and 200 activities printed/hour compared to $3.60 @ and 10/hour for manual production). . . . combined programs from Systonetics used routinely since 1972 by Associates Corp. (Indiana), a Gulf and Western subsidiary in consumer finance field, for many management functions. . . . applications include scheduling modifications or new construction in nationwide branch office system (over 900 offices), corporate planning, modeling accounts receivable and minority affairs programs. . . . very important part of multimillion dollar management system that enables company to come within 10% of time and cost estimates for projects. . . . Associates also using programs to assist South Bend (Indiana) in airport expansion project. (Personnel/contractor, Customer, TEF 517, Case Nos. 103406, 103407, 9/74)

I-2 Geodesic structure design program: developed for Headquarters by R. Buckminster Fuller at Southern Illinois University. . . . computer program used by Dome East Corp. (New York) to design commercial geodesic structures. . . . applications include recreational enclosures, greenhouses, homes and medical clinics. . . . 1973 sales $320,000. . . . $500,000-$1 million sales anticipated for 1974. . . . first domes made with plastic and vinyl coverings, but Dome East now experimenting with solid, laminated panels. (Personnel/grantee, TEF 479, Case No. 91454, 8/74)

I-3 Reinforced plastic structures: initial work under DOD contracts. . . . development continued for Headquarters, Langley, and Lewis for high performance rocket motor cases, stabilizers, and liquid hydrogen pressure containers. . . . new plastic materials commercially used by Materials Systems Corp. (California) to fabricate wall panels for prefabricated housing. . . . plastic made from petroleum refinery wastes. . . . company, which was formed by aerospace engineers in 1970, holds contract with HUD-Operation Breakthrough Program. . . . currently building 1,100 units in California, 200 in St. Louis, @ $5,000. . . . over 10% cost savings compared to conventional factory-built housing. . . . additional installations in Mexico, France and Iran. (Personnel/contractor, TEF 518, Case No. 103411, 9/74)

I-4 Fiberglass fabric: invented by Owens-Corning Fiberglas Corp. (Rhode Island) . . . . company developed first application for fiberglass fabric with 1967 contract from Johnson for nonflammable clothing and structures; included development of Teflon coating for fabric. . . . coated fabric used commercially in air structures developed by Birdair Structures, Geiger-Berger & Assoc. (New York) and others. . . . installations include a vinyl-coated fiberglass fabric covering for the U.S. Pavilion at Expo 70 in Osaka, Japan and the more commonly used Teflon-coated fabric coverings for stadiums and arenas. . . . $10 million/year industry. (Contractor, Customer/contractor, TEF 324, Case Nos. 103412, 103413, 103414, 9/74)

* Denotes transfer case related to Key Issue

I-5 Instrumentation electronics for Saturn rocket: developed for Marshall by SCI Systems, Inc. (Alabama). . . . design techniques and production methods used by SCI to design a ground fault interrupter that will fit inside a standard home circuit breaker. . . . interrupter prevents electrical accidents in home by tripping circuit breaker when ground fault current occurs. . . . required for all new homes in U.S. by 1971 Electric Code amendment. . . . normal annual rate of two million housing starts. . . . SCI sold 40,000 interrupter units/month before recent housing slump, market expected to improve. (Contractor, TEF 119, Case No. 4793, 9/74)

I-6 Cryogenic data handbook: developed for Kennedy. . . . used by Mason & Hanger-Silas Mason Co. (Kentucky), a major civil engineering firm, to design low temperature construction projects. . . . applications include at least 4 LNG storage facilities and a refrigeration system for freezing wet, loose ground during excavation in major New York City sewage system project. . . . provided 50% of input to solving serious problem in refrigeration system. . . . also used to identify substitutes for scarce materials used for corrosion control in acid plants and pollution abatement equipment. (TB/TSP, TEF 248, Case No. 9562, 8/74)

I-7 Fusion welding workmanship standards: compiled for AEC and NASA Space Nuclear Propulsion Office. . . . used by Gannett, Fleming, Corddry, Carpenter (Pennsylvania), a major civil engineering firm, to develop acceptable weld methods and to qualify welders for dam contractors. . . . saved about $250,000 on $50 million Foster Joseph Sayers Dam project (Pennsylvania) for Army Corps of Engineers. . . . current applications for Tioga/Hammond Lakes Dams, also part of Corps program in Susquehanna River basin. . . . flood control and dilution of acid drainage from coal mines. (Contact/DOD, TEF 86, Case No. 28474, 9/74)

I-8 Heat shield coating for reentry vehicles: coating composition patented by Emerson Electric Co. (Missouri). . . . first market was space program applications: coating properties determined by qualification tests conducted for NASA field centers, including Johnson and Langley. . . . coating sublimates when heated and protects substrate from high temperature. . . . Emerson employees who developed coating formed Thermo Systems, Inc. in 1967. . . . company, now called TSI, Inc. (Missouri), acquired patent rights on coating line THERMO-LAG. . . . commercial market for THERMO-LAG in construction industry is growing very rapidly. . . . reliable, effective, inexpensive fire retardant coating that protects high-rise building components, such as structural steel and electrical cables, during fires. . . . significant advance in commercially available coatings. . . . structural steel coating .2-inches thick will give two-hour fire protection comparable to four inches of concrete coating. . . . applications include high-rise motels (Florida), a pharmaceutical building (Missouri), and chemical plants (California, Texas, Colorado, Connecticut). (Personnel/contractor, TEF 521, Case No. 104141, 10/74)

I-9 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Soil Testing Services, Inc. (Illinois), a consulting engineering firm that designs foundations for buildings such as Sears Building in Chicago, to convert over 50 programs for new computer . . . . annual operating cost savings. . . . program applications include slope stability, seepage problems, and analysis of pile driver data. (TB/TSP, TFF 527, Case No. 103034, 1/75)

I-10 Deployable lattice column: designed for Headquarters study of radio telescope antenna by Astro Research Corp. (California). . . . Astro received waiver and developed commercial product, Astromast. . . . annual government and commercial sales over $600,000. . . . applications include stage light supports for traveling music show, radar beacon siting studies for FAA air traffic control system, portable power poles and communication towers. (Contractor, TFF 167, Case No. 43251, 4/75)

I-11 Linear shaped explosive charge: developed for Johnson by Explosive Technology (California) to separate stages of launch vehicles. . . . commercialized by ET as JetCord. . . . several million feet sold @ $3.48 to $45 per ft. . . . used in demolition industry for controlled removal of obselete structures. . . . more than 50 bridges and various buildings nationwide removed with JetCord. (Contractor, TFF 559, Case No. 109329, 5/75)

Other Relevant Examples:

B-11 (chemical plant design); B-19 (fire safety); D-9 (nuclear power plant design); G-10 (airport construction management); G-15 (LNG storage facilities); G-16 (fire safety); H-2 (LNG import facilities); N-7 (fire safety)

J. LAW ENFORCEMENT

Key Issue

Computerized police information systems: The first real-time police computer system was installed in 1964 for the St. Louis department. In a 1971 survey of almost 500 police departments, 38.8% of the responding departments were using computers and 62.5% would be using computers by 1974. Applications include police patrol inquiries on wanted status of individuals or property ownership, automated traffic violation records, patrolman dispatching, automated files for criminal investigations, allocation and distribution of regular patrol units, and crime statistics. The Law Enforcement Assistance Administration (LEAA) has provided federal funds to police departments for computer acquisition. Police efficiency has been improved in some, but not all, instances. In addition, a controversy exists over cost effectiveness of computer use. (J-1)

J. LAW ENFORCEMENT

*J-1 Videotape storage and retrieval system: computerized system developed for Marshall by Ampex Corp. (California). . . . NASA waived patent rights on key tape transport mechanism to Ampex in 1963. . . . improved and commercialized by Ampex as Videofile System. . . . a single tape reel stores records from 10 four-drawer file cabinets, video output is of professional quality . . . . total sales $23 million. . . . most sales to law enforcement agencies, including Royal Canadian Mounted Police ($1.1 million system in 1971), Illinois Bureau of Criminal Investigations ($1.2 million, 1972), and Louisville Police Department (Kentucky, 1973). . . . provides compact, automated fingerprint file system used successfully in all installations and criminal history files (including photographs) in some installations. . . . Canadian system will pay for itself in 3 years by reducing cost of fingerprint searches. (Contractor, TEF 226, Case No. 66201, 9/74)

J-2 Scientific and Technical Information Management System (STIMS): developed for the Scientific and Technical Information Office, NASA Headquarters, as a computer software package for storing and retrieving bibliographic materials . . . . obtained from STIF by the Law Enforcement Assistance Administration, Dept. of Justice (District of Columbia). . . . became the primary operating software for the National Criminal Justice Reference Service, a central computerized information system serving the nation's law enforcement and criminal justice agencies. . . . NCJRS (became operational in September 1972) has 30,000 registered users and performed over 300,000 searches in 1973. (Personel contact, TEF 515, Case No. 103402, 9/74)

J-3 Systems analysis and computer modeling: developed for Headquarters by Jet Propulsion Laboratory (California). . . . used by JPL Public Safety Program, under contract to Los Angeles Police Department, for requirement definition and design of proposed city-wide emergency command and control communications system. . . . includes master radio network plan, systems design for computer-assisted dispatching, automated vehicle monitoring, automated mobile command center, automated precinct command center, out-of-car communications network, and detailed specifications for mobile digital communication system. . . . will be first totally integrated system in country (cost to install over $50 million). . . . being established under LEAA funding as model program. . . . consortium of major cities established to facilitate subsequent technology transfer. (Contractor, Contact/contractor, TEF 514, Case Nos. 103399, 103400, 9/74)

J-4 California Four Cities Program: funded by NASA and NSF (since 1971) and managed by Jet Propulsion Laboratory (California) to transfer aerospace-generated technology to local governments. . . . Aerojet-General Corp. providing Pasadena with a Science and Technology Advisor and technical support. . . . Advisor used systems analysis to help Pasadena Police Department in selecting site for city heliport used by police helicopter, in compiling operations manual for effective helicopter patrol, and in developing program that reduced false alarms from burglary/robbery detection systems by 40%. (Contractor, TEF 512, Case No. 101915, 9/74)

* Denotes transfer case related to Key Issue.

J-5 Flat conductor cable connector survey: compiled for Marshall. . . . used by AMP, Inc. (Pennsylvania), manufacturer of flat cable interconnection/termination components, to increase product design knowledge. . . . components used to manufacture voice communications systems such as mobile systems used by police departments. . . . used by Spectra Associates, Inc. (Iowa) to locate flat cable hardware suppliers and to develop public safety vehicle communication system for manufacturing company client. . . . saved $200 in research time; also, reduced number of parts, saved wiring space and provided easy maintenance design. . . . client now in full-scale production of system for police departments and state highway patrols. (TB/TSP, TEF 535, Case Nos. 92532, 93278, 2/75)

J-6 High intensity arc radiation source: developed for Johnson Apollo environmental test chamber. . . . contractor personnel formed Streamlight, Inc. (Pennsylvania) to develop arc source into commercial, high intensity spotlight, called Streamlite-1 Million. . . . product has "true color," is portable, 50 times brighter than automobile headlights, and can operate from automobile cigarette lighter. . . . several hundred sold @ $400-$475 . . . . used by fire and police departments in security and emergency situations. (Contractor personnel, TEF 561, Case No. 109327, 5/75)

Other Relevant Examples:

B-13 (OSHA noise regulations); D-1 (air pollution standards); E-2 (vehicle emission certification); E-4, E-9 and H-10 (implementing air quality laws); E-6 (legal evidence); E-7 (preparing environmental legislation); F-2 (OSHA safety regulations); G-5 (environmental lawsuit); I-5 (electrical code requirements)

K. HIGHWAY TRANSPORTATION

Key Issue

Highway safety: Total economic loss due to highway accidents in 1972 was almost $19 billion. 1972 accidents caused 56,000 deaths and 4,850,000 injuries. California has largest number of fatalities, almost 10% of total. Accident rate per 100 million vehicle miles decreased from 5.5 in 1965 to 4.5 in 1972, an 18% reduction. (K-1)

K. HIGHWAY TRANSPORTATION

*K-1 Highway grooving: extensive research and testing at Langley (concept originated in England) to reduce airplane skidding on wet runways. . . . pavement grooves facilitate water runoff, improve contact between tire and surface, and reduce hydroplaning. . . . Langley results were basis for new highway/airport grooving industry with about $2 million annual business. . . . firms include Pavement Specialists, Inc. (Texas), Cardinal Engineering (Pennsylvania), Transportation Safety Systems, Inc. (Ohio), Super Cut, Inc. (Illinois), Charles R. Watts Co. (Washington), and C. W. Hatcher, Inc. (California). . . . over 25 states have contracted to have dangerous highway sections grooved . . . . wet highway accidents on grooved sections reduced by about 60%. . . . about 20% of accidents occur on wet pavement. . . . California Department of Transportation is leading user, with $8 million total outlay; applications include 400 miles of freeway grooved in Los Angeles area. . . . General Electric Co. (Ohio) produces artificial diamonds used in manufacture of groover cutting blades. . . . GE actively promoting grooving. (Contact/Langley, TEF 168, Case Nos. 101917, 101919, 101920, 101921, 101922, 9/74)

K-2 Apollo Guidance Computer software: developed for Johnson by TRW Systems (Texas). . . . used by TRW Systems (California) to develop first, real-time computerized traffic control system in U.S., SAFER (Systematic Aid to Flow on Existing Roadways). . . . prototype TRW SAFER installed and operating in 9-mile square South Bay area of Los Angeles County (California). . . . project cost about $800,000; funded by U.S. Department of Transportation Urban Systems Program (71%), County of Los Angeles (22%) and State of California (7%). . . . more than 15% reduction in millions of vehicle hours spent waiting at 112 South Bay traffic lights. . . . estimated total annual savings to motorists using South Bay streets is $1 million. . . . projected total annual savings if SAFER were installed county-wide would be $50 million. . . . TRW also installing SAFER in Baltimore, Maryland (1,000 traffic lights) and Overland Park, Kansas. (Contractor, TEF 465, Case No. 103415, 8/74)

K-3 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by Ford Motor Co. (Michigan) for design analysis of car, truck, and farm tractor components since 1971. . . . more than 40 design engineers trained to use program. . . . influenced design of every major component in these products. . . . saved two-thirds of calculating time in achieving 60% improvement for component behavior predictions . . . . reduced R&D time and cost, as well as development testing costs (no valid cost savings figure available at this time). . . . General Motors Corp. (Michigan) recently completed development of design application methods to facilitate NASTRAN use by design engineers. . . . program calibrated with data from older vehicles. . . . corporate effort aimed at widespread use of NASTRAN in product design. . . . NASTRAN versatility and continued program maintenance service from Langley are very important to Ford and GM. (Contact/COSMIC, TEF 410, Case Nos. 103416, 103417, 9/74)

* Denotes transfer case related to Key Issue.

K-4 Saturn I/IB Systems Development Breadboard Facility: installed and operated for Marshall by Chrysler Corp. (Alabama). . . . electronics design, computer systems, and quality production experience at Huntsville Div. used to develop new products and production line testing for most Chrysler cars and trucks . . . . annual production 2 million units. . . . product applications include hybrid circuitry in new solid-state radios for Plymouth and Dodge lines, accurate digital clock for Chrysler line, and ignition retarder to reduce emissions when idling. . . . more durable radio uses 20% of electricity previously required. . . . production applications include methods to produce reliable electronic ignition systems used in all cars and light trucks, automated electrical wiring test system for some car assembly plants, computerized system for automated testing of car distributors and windshield wiper motors, and semiautomated test system for brake cylinders. . . . electronic ignition system is a major improvement in car equipment, better car performance reduces emissions and lowers maintenance cost. . . . 60-second test of car wiring identifies whether rework is needed. . . . 8,000 distributors tested daily at 60 secs. each, with 10 times previous accuracy. . . . brake cylinders tested in 7 secs. (Contractor, TEF 507, Case No. 101927, 9/74)

K-5 Combustion analysis computer program: developed by Lewis. . . . routinely used by General Motors Corp. (Michigan) since 1970 in combustion research for automotive engines. . . . by modeling the engine combustion process, program improved analysis of how pollutants are formed. . . . research results used in various GM design and development projects. . . . used extensively by Chrysler Corp. (Michigan) in combustion analysis for gas turbine engine development. . . . gas turbines will be introduced in 1975 automobiles. . . . lower emissions and fewer moving parts than standard piston engines. (Contact/Lewis, TEF 463, Case Nos. 103409, 103410, 9/74)

K-6 Statistical procedures to analyze time-dependent data: developed for Marshall . . . . used by General Motors Corp., Saginaw Steering Gear Div. (Michigan) to analyze noise test data from automobile steering systems and other components. . . . enabled analysis of output from sophisticated new test instrument; saved testing time and reduced costs on a continuing basis. . . . test results used to reduce noise caused by Saginaw components in GMC passenger cars. (TB/TSP, TEF 545, Case No. 87348, 3/75)

K-7 Rubber tire with low temperature pliability: developed for Johnson Apollo 14 Mobile Equipment Transporter by Goodyear Tire and Rubber Co. (Ohio). . . . used by Goodyear to develop new, studless winter automobile tire. . . . market testing started in 1974 with 4 cities; received good response. . . . price range from $71.25 to $79.45, with 4 sizes available. . . . provides traction equal to or better than studded tires on slick surfaces; also good traction on dry surfaces. . . . . several states are banning studded tires due to poor traction on dry surfaces and destruction of road surface. (Contractor, TEF 565, Case No. 109331, 5/75)

Other Relevant Examples:

A-1 and A-6 (automobile products); B-9 (lubricant for car air conditioners); B-22 (automobile components); D-2 (vehicle emission certification); H-11 (vehicle emission control)

L. RAIL TRANSPORTATION

Key Issues

a. Railroad safety: Train accidents caused by improper maintenance increased 300% between 1961 and 1972, and all train accidents increased 25% between 1972 and 1973. Increased use and deferred maintenance of track are major factors in these rises. Over 90% of railroad revenue is from freight service which, growing at 3% annually, totaled 877 billion ton-miles in 1974. The average freight car capacity was 53 tons in 1950 and 68 tons in 1971, but the average capacity of new cars built in 1973 was 85 tons. The average use factor for freight cars is also increasing: in 1973 this was 1,621 ton-miles per car-day, an increase of 9.5% over 1972. Greater use of unit trains, particularly for hauling coal which makes up 26% of rail freight tonnage, is a major cause for the use factor increase since unit train cars annually travel 3-16 times further than ordinary cars. In 1960 the railroads spent $1.2 billion to maintain structures and 219,400 miles of road; in 1972 these figures were $1.9 billion and 208,000 miles. Expenditures for maintenance and the importance of inspection equipment will continue to grow. (L-1)

b. Railroad computer systems: For some time, many railroads have used computers for data analysis and planning at central offices. Some railroads started using computerized information systems in the late 1960's to handle enormous amounts of paper such as waybills (railroad freight documentation). Since 1970 there has been a rising interest in computerized process control applications such as terminal operations and train dispatching. These real-time applications require much more sophisticated computer and communication systems and man-machine interfaces. To date, only one or two prototype systems of this sort have been installed for pilot testing. Computers are currently used in a few rail yards for monitoring and assisting in terminal operations. Between 1975 and 1980, the railroads will install a national freight car information system, TRAIN II, that was pilot tested in 1974. This computerized information system is expected to improve car utilization and to help forecast future needs by updating information such as car location and status on an hourly basis, as compared to the present daily basis. (L-2 and L-4)

L. RAIL TRANSPORTATION

*L-1 Ultrasonic nondestructive testing techniques: developed for Marshall and Johnson by Automation Industries, Inc. (Connecticut). . . . company had over $2 million in contracts to produce innovative equipment for Apollo Program in past few years and has "had commercial spin-offs of several times that amount". . . . for example, Marshall funded the development of company's laboratory prototype into operational ultrasonic Delta Manipulator which Automation then marketed. . . . uses multiple transducers for significant improvement in testing rate and accuracy. . . . delta technique and ultrasonic test equipment now used by Automation in unique rail inspection service. . . . company has operated self-propelled railroad cars since 1928 to detect rail flaws with electric induction technique. . . . currently, 28 cars in operation on U.S. rails, 1 in Mexico, 2 in Australia, and others in Europe. . . . all cars now include ultrasonic test equipment, many use delta technique, and new cars use ultrasonics entirely. . . . one of the all ultrasonic cars used exclusively on New York City Transit Authority subway rails. . . . ultrasonics used to detect rail-end flaws (e.g., bolt hole cracks) and to complement induction method along rail. . . . over 500 million rail joints tested ultrasonically. . . . company does majority of NDT for U.S. rails; only one other NDT car exists, developed by a railroad. . . . since 1928 over 6 million miles of track tested; over 3 million flaws detected and track replaced. . . . over 160,000 miles of track now tested annually for 100 different railroads. . . . average testing speed for test cars is about 7 mph. (Contractor, TEF 387, Case No. 59201, 8/74)

*L-2 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (Texas). . . . used by TRW Controls (Texas) to develop software and telemetry interface equipment in prototype computerized dispatching system for railroads. . . . prototype installed and being tested in part of Southern Pacific Co. (California) railroad system. . . . one of most sophisticated train control systems in world. . . . TV displays provide central dispatcher with continually updated status of rail switches and trains; system provides for control of rail switches and train movement via light pen input on TV display. . . . test results favorable to date. . . . if prototype successful, Southern Pacific and TRW will develop computerized dispatching system for company's entire railroad system. . . . Southern Pacific is one of 3 largest railroads in nation; 4,000 miles of track, $1 billion annual freight billings. (Contractor, TEF 465, Case No. 86005, 8/74)

L-3 Dynamic and static modeling techniques: developed by Marshall. . . . used by Martin Marietta Corp. (Colorado) in current development of dynamic model for railroad hopper cars. . . . TUO applications engineering project funded by Federal Railroad Administration and under technical direction of Marshall. . . . part of a major test program being conducted by Association of American Railroads to reduce number of derailments which are frequently caused by erratic behavior of hopper cars. . . . hopper car testing and model development underway at Martin to identify design modifications that will reduce erratic behavior. (TUO-Applications Engineering, 1/75)

* Denotes transfer case related to Key Issue.

*L-4 Videotape storage and retrieval system: computerized system developed for Marshall by Ampex Corp. (California). . . . NASA waived patent rights on key tape transport mechanism to Ampex in 1963. . . . improved and commercialized by Ampex as Videofile System. . . . a single tape reel stores records from 10 four-drawer file cabinets. . . . important advantages over microfilm and closed circuit systems include reduced processing for storage and improved resolution. . . . $750,000 Videofile System used by Southern Pacific Co. (California) since 1968 for all documentation related to railroad freight (waybills). . . . Southern Pacific among the 3 largest railroads in nation, $1 billion annual freight billings. . . . revenue settlement between railroads can take 3 years due to massive paper problem. . . . ICC requires 4-year storage of waybills. . . . Southern Pacific's Videofile in use 24 hours per day, 5 days per week; 500,000 waybills entered per month and 100,000 retrieved . . . . system cost recovered in about 4 years through reduced operating costs. (Contractor, TEF 226, Case No. 66201, 9/74)

L-5 Arc suppression techniques evaluation: conducted for Marshall. . . . used by Vapor Corp. (Illinois) in design of rapid transit switch control products . . . . allowed designers to eliminate expensive capacitors and select diodes that are now used in 80% of product circuitry. . . . prevents high voltage direct current arcing in switch equipment; increases reliability and reduces cost to customer. (Professional Journal/TSP, TEF 128, Case No. 1520, 10/74)

L-6 Model for hazardous materials plume dispersal (to determine evacuation area): developed by Lewis for the Joint Army-Navy-NASA-Air Force (JANNAF) Safety and Environmental Protection Working Group. . . . used by Chemical Propulsion Information Agency at Johns Hopkins University (Maryland), under contract to Department of Transportation, to develop "Emergency Services Guide for Selected Hazardous Materials". . . . procedures for tank car spills of 30 hazardous chemicals are presented. . . . almost 100,000 copies of guide have been distributed, primarily to police and fire departments throughout the country. (Interagency, TEF 550, 1/75)

L-7 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by Langley to select rail installation procedures for DOT's High-Speed Ground Test Center (Colorado). . . . procedures used to prevent buckling of linear induction motor reaction rails. . . . successful operations at test center since 1972 rail installation. . . . used by Pullman, Inc., Pullman-Standard Div. (Illinois) in 3-year project to develop new family of open-top railroad car. . . . significant design improvements provide more efficient, rugged car for bulk commodity transport. . . . company built new production facilities to manufacture the 7 new gondola and hopper car designs . . . . major industrial and railroad firms have ordered fleets of the new cars . . . . Pullman is world's largest producer of railroad cars. (Contact/Langley, TEF 410, 1/75)

* Denotes transfer case related to Key Issue.

M. AIR TRANSPORTATION

Key Issue

Aircraft research and development: Company-funded R&D in the aerospace industry cost $1.01 billion in 1971 and is projected to cost $1.15 billion in 1975; total company-funded R&D for all industries was $10.64 billion in 1971 and is projected to reach $13.95 billion in 1975. In 1971, the total R&D activity by scientists and engineers was 359,700 man-years, 21% (or 75,100 man-years) was aerospace and 5% (or 18,400 man-years) was company-funded aerospace. The civilian aircraft industry has relied heavily on government-funded projects to develop and "prove out" new concepts in aircraft design. New designs from NASA and DOD research facilities are typically used first in military aircraft and then in civilian aircraft in order to sustain the continued growth in performance for both types of aircraft. Manufacturer shipments of complete civilian aircraft were: 14,660 units worth $3.5 billion in 1967; 7,644 units worth $3 billion in 1971; and (projected) 15,500 units worth $5.7 billion in 1975. About 80% of the shipment value is due to a relatively small number of large commercial transports (480 in 1967, 223 in 1971, and 304 in 1975). Performance advances have maintained U.S. aircraft domination of world markets. The total aerospace export value hit an all-time high of $7 billion in 1974 ($2.8 billion for 230 large transports) and is projected to be $7.9 billion in 1975 ($3 billion for 240 large transports). (M-1 and M-2)

M. AIR TRANSPORTATION

*M-1 Aircraft design concepts: developed by Langley since early 1950's to improve military and civilian aircraft. . . . conducted design development from conceptual stage, through wind tunnel testing, to flight demonstrations for aircraft industry. . . . contributions significantly advanced body/wing designs for supersonic military aircraft, large subsonic air transports, and light planes. . . . area rule of selecting body/wing cross section design for minimum drag is exemplefied by "coke bottle" shaped body. . . . used worldwide to design supersonic military aircraft. . . . air transport applications include the humped cab on Boeing Co. (Washington) 747. . . . supercritical wing design that can increase subsonic cruise speed by 15%, or decrease fuel consumption by 15%, or a combination of the two. . . . also, general aviation version of supercritical wing. . . . used by nearly all major aircraft manufacturers in current development of most new air transports and light planes. . . . company-funded R&D for aircraft industry was $1 billion in 1971 (out of $10.6 billion total for private R&D) and projected at $1.1 billion for 1975 (out of $13.9 billion total for private R&D). . . . only the electrical equipment industry spends more to develop new products. (Contact/Langley, 1/75)

*M-2 Aircraft design data: obtained by Langley wind tunnel and flight testing programs. . . . tests in late 1940's and 1950's reduced swept back wing concept (a German invention) to engineering practice. . . . design now used for all air transports. . . . tests of engine/wing aerodynamics for Air Force C-5 transport resolved aircraft contractor's (Lockheed) design problems in mounting new generation of large fan turbines on wings. . . this major contribution to design capability used to mount same generation turbines on commercial air transports; McDonnell Douglas Corp. (California) DC-10 and Lockheed Aircraft Corp. (California) L-1011. . . . DC-10 development cost McDonnell Douglas $1 billion. . . . test facility provides basic data which reduces development costs for civilian and military aircraft designers. (Contact/Langley, 1/75)

M-3 Liquid penetrant nondestructive testing training manuals: compiled for Marshall . . . . used to train and certify production line inspectors at Beech Aircraft Corp. (Kansas). . . . 80 inspectors at 4 plants. . . . very important in quality control. . . . second largest producer of business and utility aircraft. . . . 1973 sales about $160 million. (TB/TSP, TEF 374, Case No. 40622, 8/74)

M-4 Computer display system for Saturn prelaunch checkout: developed for Marshall and Kennedy by Sanders Associates, Inc. (New Hampshire). . . . significant advances in digital television hardware and software for computer interface systems. . . . used by Sanders to develop commercial product line in 1968. . . . price range $70,000 to $125,000; 30 units sold by 1972, with additional sales (unknown) since then. . . . applications include pilot training simulators, flight test monitoring, and air traffic control. . . . used in $700,000 display portion of $3.5 million computer system for 1970 flight testing of McDonnell Douglas Corp. (California) DC-10. . . . automated data analysis reduced total test flight hours from projected 2,000 to actual 1,250. . . . used in new Canada-wide air traffic control system; multimillion dollar display portion is 75% installed. (Contractor, TEF 99, Case No. 76502, 1/75)

* Denotes transfer case related to Key Issue.

M-5 Inertial navigation equipment for Apollo and Lunar Module: developed for Johnson by General Motors Corp., Delco Electronics Div. (Wisconsin). . . . hardware designs and expertise used by Delco to develop aircraft inertial navigation equipment, Carousel IV product line. . . . 39 airlines use Carousel IV units in air transports. . . . majority of inertial units in commercial aircraft are Carousel IV; standard equipment on Boeing Co. (Washington) 747, other installations on DC-8's, DC-10's and 707's. . . . provides self-contained navigation system; independent of magnetic, radio, or radar aids and of weather or man-made interference. . . . pilot provides start and destination points; unit calculates shortest course and can automatically steer via autopilot equipment. . . . saves time and fuel. . . . tests by a major airline proved Carousel IV to be 5 times more accurate than standard navigation method. (Contractor, TEF 170, Case No. 44787, 1/75)

M-6 Aircraft Materials Development and Evaluation Program: conducted by Johnson, in cooperation with FAA and aircraft industry, to develop better fire protection for passengers and aircraft. . . . testing new, improved nonflammable materials for furnishings under realistic conditions in Boeing 737 fuselage donated by United Airlines. . . . test results providing baseline data for industry to evaluate new materials and for FAA (District of Columbia) to set practical fire safety standards on cabin furnishings. (Interagency, TEF 548, Case No. 107736, 12/74)

M-7 Airport runway grooving: extensive research and testing at Langley (concept originated in England) to reduce airplane skidding on wet runways. . . . pavement grooves facilitate water runoff, improve contact between tire and surface, and reduce hydroplaning. . . . 40-50 runways have been grooved in cities such as Miami, Atlanta, Denver, Chicago, Detroit, Kansas City, Mo., New York, Dallas-Ft. Worth, Boston and St. Louis. . . . Washington's National was first in U.S. (1967). . . . some have been grooved during construction, others after being cited as dangerous by the Air Line Pilots Association. . . . grooving endorsed by FAA, ALPA and airlines. . . . pavement grooving is a $2-2.5 million industry . . . . less than ten firms involved in grooving in the country, e.g., Pavement Specialists, Inc. (Texas); Cardinal Engineering (Pennsylvania); Transportation Safety Systems, Inc. (Ohio); Super Cut, Inc. (Illinois); Charles R. Watts Co. (Washington); C. W. Hatcher, Inc. (California). (Contact/Langley, TEF 168, Case Nos. 101916, 101917, 101918, 101919, 101922, 9/74)

M-8 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (California). . . . used by TRW Data Systems (California) to develop Validata service. . . . largest private computer system used by nationwide travel industry in checking credit cards, personal checks, airline tickets and other non-cash payments. . . . system has 10 million credit records in central computer. . . . over 1,000 subscriber terminals in 141 localities throughout U.S. (hotels, airline ticket offices, and 35 airports) . . . . each subscriber inquiry takes less than 3 seconds to process and subcription fee per inquiry ranges from 2 cents (ticket) to 8 cents (personal check). . . . over 11 million inquiries processed since 1972; responsible for stopping bad credit transactions worth $8 million. . . . caused major reduction in use of stolen tickets. . . . subscribers include: (airlines) Continental, Eastern, Hughes Air West, Japan, Lufthansa, Mexicana, Northwest, PSA, Qantas, TWA, Western; (car rental agencies) Hertz, National, Budget; and (hotels) Holiday Inn, Marriott. . . . credit data from service also used in American Airlines and United Airlines reservation systems. (Contractor, TEF 465, Case No. 104260, 1/75)

M-9 Combustion analysis computer program: developed by Lewis. . . . used by General Motors Corp., Detroit Diesel Allison Div. (Indiana) to analyze turbo-prop aircraft engine product designs. . . . daily application in research program to reduce air pollution from engines. . . . benefits include convenience, speed of calculation, accuracy and low cost. . . . major producer of turbo-prop engines. (Professional journal, TEF 463, Case No. 103408, 9/74)

M-10 Friction characteristics of graphite and graphite-metal: developed for Space Nuclear Propulsion Office. . . . used by B.F. Goodrich Co. (Ohio) in successful R&D project related to brake products for commercial aircraft. . . . used by Dover Corp., Cook Airtomic Div. (Connecticut) to develop prototype product for aircraft gas turbines. . . . prototype graphite-nickel valve rings successful in flight and ground tests on Pratt & Whitney JT9 turbines. (TR/TSP, TEF 555, Case Nos. 51732, 73982, 4/75)

Other Relevant Examples:

B-2 and B-2 (aircraft production quality control); B-10 (fracture toughness tests); C-3 (Rogallo wing); C-7 (life raft); F-11 (aircraft galley refrigerator); G-10 and I-1 (airport construction management); K-1 (pavement groover); O-5 (NDT training service); O-7 (technician training)

N. INSURANCE, BANKING, AND REAL ESTATE

Key Issue

Electronic funds transfer: The number of commercial banks has remained at about 14,000 since 1946; the number of bank branches, however, increased from 14,000 in 1960 to almost 27,000 in 1973. The total demand deposits have increased from $248 billion in 1970 to $322 billion in 1974 and are projected to be $383 billion in 1980. An estimated 40 billion checks will be written in 1980 on one kind of demand deposit--the checking account. A 1968 survey of almost 1,000 banks indicated that computer automated funds transfer was being used by 71% for demand deposit accounts and by 52% for time deposit accounts. A 1969 survey of 40 banks found that the use of a computer for demand deposit operations reduced personnel requirements by 10-67%. The use of automated, tellerless bank facilities is increasing rapidly due to the competition between banks in providing greater customer convenience and to the availability of satisfactory commercial systems. A national automated clearinghouse for interbank exchange of paperless entries is under active consideration by the American Bankers Association. (N-1)

N. INSURANCE, BANKING, AND REAL ESTATE

*N-1 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (California). . . . used by TRW Data Systems (California) to develop computerized financial communications systems for banks, savings and loan associations, and the Federal Reserve System. . . . major producer for new generation of on-line equipment for account information, automatic funds transfer, and tellerless banking. . . . advantages include 30% faster transactions, rapid installation and servicing, quick teller training, and elimination of almost all normal teller entry errors. . . . market for such systems growing exponentially, and TRW has 20% share. (Contractor, TEF 465, Case No. 104260, 10/74)

N-2 Videotape storage and retrieval system: computerized system developed for Marshall by Ampex Corp. (California). . . . NASA waived patent rights on key tape transport mechanism to Ampex in 1963. . . . improved and commercialized by Ampex as Videofile System. . . . a single tape reel stores records from 10 four-drawer file cabinets. . . . total sales $23 million. . . . American Republic Insurance Co. (Iowa) installed Videofile in 1972 for all insurance records. . . . provides claims and rate analysts with immediate access to records. . . . system is faster and minimizes chance of error. (Contractor, TEF 226, Case No. 66201, 8/74)

N-3 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Computer Directions Advisors, Inc. (Maryland) to convert in-house programs for use by clients using different types of computers. . . . programs part of investment research services for institutional investors. . . . guide increased service capability and reduced operating costs . . . . used by Price Waterhouse & Co. (New York) to convert an in-house statistical analysis program for use by its 300 worldwide field offices when conducting on-site audits for clients. . . . use of program increases reliability of auditing services, providing company clients with more thorough audit . . . . used by Economics Research Associates (California) as reference for running in-house economic model programs on three different, time-shared computer systems. . . . company's economic modeling services used for large-scale land development and recreational projects. . . . anticipated $2,000 savings in future when programs are fully converted. (Trade journal/TSP, TEF 527, Case Nos. 102198, 102294, 102924, 1/75)

N-4 Safety yoke for construction workers: developed for Kennedy. . . . used by insurance companies to provide customer services and reduce industrial accident claims. . . . Industrial Indemnity Co. (California) distributed copies to clients in construction industry. . . . at least two clients are using yoke. . . . company writes $300 million worth of insurance annually. . . . Employers Insurance of Wausau (Wisconsin) distributed copies to its construction safety specialists. . . . specialists now advising industrial clients to use the yoke. . . . company writes $400 million worth of insurance annually. (Trade journal/TSP, TEF 103, Case Nos. 10323, 18072, 12/74)

* Denotes transfer case related to Key Issue.

N-5 Microbiological Handbook: compiled for Marshall. . . . used by insurance companies for industrial customer services and accident claims reduction . . . . Commercial Union Assurance Co. (Massachusetts) used handbook to prepare manuals and training programs for regional office field engineers who inspect policyholders for safety regulation compliance. . . . Employers Insurance of Wausau branch office (New Jersey) used handbook to solve problems for two policyholders. . . . eliminated dermatitis claims with new decontamination procedure for industrial plant and implemented new sterilization procedure for hospital. . . . important industrial hygiene reference . . . . Liberty Mutual Insurance Co. branch office (Georgia) also used handbook as industrial hygiene reference. . . . provided industrial policyholder with new decontamination procedure. (Professional journal/TSP, TEF 402, Case Nos. 58500, 61395, 87001, 12/74)

N-6 Hazardous materials safety handbook: compiled at Lewis. . . . used regularly by Shelby Mutual Insurance Co. (Ohio) in loss prevention service for industrial policyholders. . . . handbook and numerous TSP's received by company over last 7 years have been very useful in program for cross-training service representatives and adjusters. . . . program goal is to reduce number of employees needed to write $1 million worth of insurance from 19 down to 10 . . . . management TSP's used by company president. . . . appropriate process TSP's forwarded to industrial clients. . . . company writes $71 million worth of property and casualty insurance annually. (Contact/Lewis, TB/TSP, TEF 250, Case No. 13315, 8/74)

N-7 Flammability tests of home furnishings: conducted for TUO by Battelle Columbus Laboratories to compare performance of aerospace materials with conventional furnishing materials in full-scale bedroom fires. . . . report used by Factory Mutual Research Corp. (Massachusetts) to design a full-scale, flame-spread test for residential units; part of applied research program for the Factory Mutual Insurance System. . . . used by Liberty Mutual Life Insurance Co. (Illinois) to provide field inspectors in midwest division with information on new, nonflammable aerospace materials; information intended for use in conducting better analyses of building and room combustibility. . . . also used by Marsh & McClennan Insurance Brokers (New York) to provide selected clients and field inspectors with data on the new materials. (Contact/TUO, Professional society, TEF 539, Case Nos. 107052, 107053, 107054, 1/75)

Other Relevant Examples:

G-2 (land use planning); G-5 (land use law suit)

O. EDUCATION

Overview of benefits to education taken from The Impact of the Space Age on Education in the United States, Staff Report prepared for the use of the Committee on Astronautics and Space Sciences, United States Senate, November 2, 1972.

[Introduction]". . . perhaps the most important and lasting impact of the entire space effort in the United States is and will continue to be in the field of education, the field from which the space age was born. . . . Many educators agree that the space endeavor has steadily upgraded the educational system in America. Initially, this upgrading was centered in the sciences, but gradually it spread over much broader areas in order to balance the emphasis in all fields of learning. In all, it is hard to imagine a school system that has not been affected by the space effort. In these days of orbiting satellites and manned missions into space, teachers must be ready to explain what causes a satellite not to fall and how a man can walk in space so easily. Teachers of many different subjects must be able to work with students who inquire about the practical applications of such subjects to space activities. . . . Sputnik assuredly solidified the recognition of the weaknesses in American education and served as a catalyst in generating the resources for improvement. During the course of the dramatic events that followed, a thorough analysis of the educational system took place as a necessary step toward producing the highly competent scientists needed for the United States to regain its position of world leadership in the new era.

[Elementary and Secondary Education]". . . Before Sputnik, the need for curriculum revision in the elementary and secondary schools was recognized by only a few people, and, as a result, the resources available to make significant changes were sparse. . . . the traditional methods of mathematics education were not meeting the new demands of a technological society; and this fact became a grave matter for thought and subsequent action. After mathematics, educators were concerned with upgrading foreign language instruction and science education, particularly the physical and biological sciences. The social sciences lagged miserably behind and had to be improved, but by 1966, they were only at the level the natural sciences had been nearly a decade earlier. During 1965, attention began to be concentrated on the humanities in order to have a completely well-rounded educational curriculum in the United States.

. . . "The curriculum reform effort was generally marked by a substantial revision of content, a reorganization of subject matter, and the adoption of many fresh approaches to methodology in traditionally taught school courses. In general, the overall trend was toward the introduction of special courses, the use of new subject matter materials, increased use of students' interest in space-age ideas and information, and provision for improved coordination of class instruction from the kindergarten up to the twelfth grade. Since the various curricular materials were planned by top-flight physicists, mathematicians and historians, students were therefore encouraged to think as did the scholars. . . . As early as 1960, a new topic was introduced into several school systems--aerospace and all of its ramifications. . . . The subject of aerospace was often taught as part of an astronomy unit or course, or

integrated in other fields; but sometimes the subject stood alone as a field to be studied. . . . [NASA] played a key role in developing source materials for teachers of all grades in space-oriented mathematics. . . . to assist teachers in bringing to their students a comprehension of space and the problems of its exploration by using the mathematical skills the students already possessed or were in the process of learning. Such topics taught included data treatment, a new numeration system, scale drawing, and space time. . . . The Educational Programs Division of [NASA]. . . undertook to prepare and make available space-related curriculum supplements for secondary school teachers of different science subjects. The supplement on biology is the only science resource unit published through 1969. But the pattern is expected to be similar in all sciences. The other curriculum supplements are in mathematics, physics, chemistry, space science, and physical science. . . . tryout and evaluation of the NASA supplement on space biology for high school students, was conducted during the summer of 1967. This experiment was deemed a success and the course went into various school systems.

". . . Many basic general science textbooks devoted whole units or chapters on space study. Examples include a 73-page unit entitled "Instruments and Techniques for Space Study" from the sixth grade text Science and Life used in parochial schools. . . A 95-page resource unit entitled Exploring Space was provided for in a physical science course in the secondary school curriculum for the New York State Education Department. Such topics as the earth's atmosphere, exploring space from the earth, and exploring outer space were included. . . . [in 1957] there were 177 inexpensive paperback books on science in print; 5 years later, there were in excess of 900. The educational journals published in the United States contained an average of 340 articles on science education in each year between 1948 and 1954; but then, for the 4 years after 1957, this yearly average rose to 535. In the nonprofessional magazines prior to 1958, there appeared approximately 20 articles every year on science education. For the next 4 years, however, the same magazines averaged 151 articles annually on science education. . . . [a 1961 survey of the State Supervisors of Science in 50 states and the District of Columbia] revealed optimistic trends in space education throughout the United States. Sixty percent of the replies indicated that States had introduced courses of study in the area of earth and space science into their school curriculum. . . . 75 percent reported that courses in earth and space science would encourage more capable students to enter these study areas in college.

". . . By 1968, such polished course materials as the "Lincoln Plan, Introducing Children to Space" was produced by the Lincoln, Nebr., Public Schools for grades kindergarten through six. Another example of space instruction was developed in the Pennsylvania Earth and Space Science Improvement Program by the State's Department of Public Instruction for elementary and secondary levels. . . . basic trends have taken place in social studies curricula to introduce space age topics. . . . increased use of newspapers, news magazines, and current events weeklies in the classroom. Through these materials teachers taught the most important topics of the space age which included scientific change, political and economic developments, and social problems. . . . addition of new study topics on the space age in social studies programs, especially at the junior high school level.

For example, a seventh grade geography course would offer such topics as: The World--Its Place in the Universe, Our Earth in Space, Space-Age Geography, Local Industries Related to the Space Age, the Space Age of Tomorrow, or Space Progress in Foreign Affairs. . . . Much of the widespread attention given to scientific activities and topics was evidenced by the growth of memberships in young people's scientific associations and programs. The Young Engineers and Scientists of America was chartered in 1959. As of 1965, it had 250 chapters in 36 States and 7,500 students as members. The Junior Engineering and Technical Society, chartered in 1958, had as of 1965 a total of 100 chapters in 46 States and a membership of 35,000. The Junior Science and Humanities Symposia program, initiated in 1958, as of 1965 had a total of 6,000 students participating in 20 States. The Science Clubs of America program included more than 25,000 clubs enrolling close to 650,000 students in every State. . . . an important and continuing resource in space age education are the lectures in various areas of aeronautics and space. These include lecturers supplied by the National Aeronautics and Space Administration. In addition, there are other private and public specialized resources and free direct assistance such as NASA publications, films, video tapes, exhibits, field trip opportunities, and aid in planning, organizing, and conducting institutes and courses. These services and aids have been invaluable to educators and their students.

[Higher Education]. . . Changes in college curricula have been widespread in colleges and universities at both the undergraduate and graduate levels. Much has been done in curricula revision to relate the liberal or general education of students to the space age. For example, many traditional first and second year courses were found to be below the level that newly admitted high school students needed because of their previous upgraded education. Because of this situation, colleges found it necessary to step up their courses and make them more relevant to the world of the space age. Most major colleges and universities have programs or courses in space sciences and related fields. As of 1968, a total of 80 institutions offered courses leading to degrees in some kind of space-related field. Some professional schools such as those granting degrees in law and medicine, offer courses or materials relating to space in connection with traditional courses. Perhaps more important, however, is the impact of the expansion of research activities related to space problems in the universities with substantial governmental support. This expansion is also reflected in new buildings and equipment, school and departmental reorganizations, and changes in administration and services.

". . . In 1959, NASA provided a total of only $3 million to support research in colleges and universities. By 1966, the amount had jumped to $128 million. The major spurt took place in 1962, when NASA initiated its Sustaining University Program. The funds from this program were allocated for supporting graduate traineeships, campus research, and new facilities. In the first decade of the space age, NASA made direct contributions of nearly $700 million to over 200 universities and colleges across the United States. Nearly $500 million of this total was for work in direct support of specific space projects. The other $200 million went into student grants and into new or improved laboratories and other research and teaching facilities. Another striking swing is evidenced by NASA's

allocation of $2 million to support predoctoral training. By 1964, this agency was spending $20 million annually to produce highly skilled specialists demanded by the space age.

[Educational Television Satellites]". . . The idea of using satellites as a tool in education was first put forward at the 1960 General Conference of UNESCO by the French philospher, the late Gaston Berger. . . . The scientific advances and developments being made possible by the use of satellites and other features of the United States space effort have induced changes in this country's patterns for doing and for living. The rapid rate in which these changes are coming about is the dominant fact of the era of the space age. . . . What has been and is being accomplished. . . gives education new frontiers and new dimensions. . . . space communications properly employed can enhance the possibility for education to win the race with time, especially in the developing countries. Traditional school systems recently have been expanding at a remarkable rate, but the addition of space communications in the countries not yet served would permit a wide geographical extension of improved education. Continuing education all over the world and mass education in the developing countries emerge as systems in which the teacher and the pupil are necessarily separated from one another because of distance, the deficiency of schools, or the dispersion of classes. . . . Eventually, satellite television could give every classroom a window to the world.

[Conclusion]". . . in the words of Vice President H. Humphrey in 1966: 'The space age has placed a premium on knowledge and education. It has also forced us to adopt higher standards throughout our society.'. . . The space age has uncovered a wealth of knowledge by creating an atmosphere where education is sought after and highly respected. And with this came a recognition of the need for better teacher-training to meet the requirements stemming from the expanding role in our society of such subjects as mathematics, science, and technology with a growing emphasis on subject matter as well as on educational techniques. . . . Every level of organized education has directly or indirectly requested NASA to help satisfy an amazing thirst for information about space science and technology.

. . . [Children of the space age] "feel all the educational pressures placed on them in this era. These range from pressures experienced as the result of a tougher elementary curriculum to those of getting into college and going on for graduate degrees. However, they may experience an inner conflict. On the one hand, they expect and want much more from the advanced and sophisticated technological space age society to improve our global social structure and well-being. On the other hand, they despise the mechanical, dehumanizing rapid pace of society which appears to them to overlook world problems such as poverty and to provide the wherewithall to over-meddle in the world political problems. . . . Newsweek's July 7, 1969, issue. . . featured an article entitled 'The Moon Age'. . . [which] said in part:. . . Children find space exploration about as miraculous as the television sets they watch it on. Why does man go to the moon? Because it is there. Where? Right there, on Channel 2, and can I please stay up a half hour late tonight to see if the astronauts find anything good on the moon when they get there?. . . No American child worth his salt, pepper or Pablum has any doubts that they'll get there (the moon). How far, after all, is the moon from the earth? Precisely the same distance as Vietnam--across the living room."

O. EDUCATION

O-1 Flight path simulator: developed at JPL to show interplanetary satellite flight paths. . . . patent rights waived to California Institute of Technology. . . . licensed by Cal Tech to Hubbard Scientific Co. (Illinois) in 1968. . . . company commercialized the invention as a Planetary Celestial Globe product. . . . 1,000 globes sold at $60 each. . . . globes used in junior high schools to illustrate interplanetary motion. (License/contractor, TEF 154, Case No. 106372, 12/74)

O-2 Hybrid computer: purchased by Aerojet-General Corp. (California), while under contract to Lewis and Space Nuclear Propulsion Office, to simulate space nuclear power sources. . . . used by Aerojet in 1967 to design computerized anesthesiology simulator, SIM I, for the University of Southern California. . . . USC held contract from HEW to develop the simulator. . . . SIM I provides medical students with "hands on" experience in performing endotracheal intubation, a vital respiration procedure involved in 75% of all operations. . . . computer used to simulate interrelationships between life signs, enabling SIM I to exhibit variety of life-like reactions to the respiration procedure. . . . original unit used daily for 8 years by USC medical students. . . . Sierra Engineering Co. (California) licensed by USC to manufacture commercial version of the simulator. . . . Aerojet and Sierra working with USC to develop SIM II, a portable model designed for use in emergency medical training programs. (Contractor, TEF 528, Case No. 106373, 1/75)

O-3 Phonocardiogram simulator module: developed at Kennedy to calibrate astronaut monitoring instruments. . . . module supplied by Kennedy to University of Kentucky. . . . used in prototype mother/child birth simulator developed and patented by the University; NASA module imitates baby heartbeat which can be varied to simulate different childbirth conditions. . . . simulator an important component of the University's College of Nursing self-instruction laboratory. . . . 200 nursing students received childbirth training with this prototype. . . . also, students at Lexington Community College (Kentucky) gained similar experience with portable version of simulator. . . . use of birth simulator eliminates tension caused by live birth training. . . . NASCO (Wisconsin) licensed by Kentucky to manufacture simulator. . . . 1975 production planned for $500 unit for training high school students, fire and police department personnel. . . . 1976 production planned for more complex models in $1,000 to $1,500 range for paramedic and nurse training. . . . need for medical training simulators is increasing because national medical programs, such as Medicare, are reducing number of patients who are willing to be treated by supervised students in order to receive free medical services. (TB/contact with Kennedy, TEF 274, Case Nos. 82701, 107062, 12/74)

O-4 Soldering school: held at Ames. . . . center provides facilities, books, materials, and some instructors to train people in high quality soldering of electronic components. . . . 4-week course for experienced personnel, 6-week course for beginners. . . . 635 people trained since 1963. . . . total includes NASA, DOD and contractor personnel, as well as high school shop instructors and students (32), Mountain View High School Adult Education (California) participants (16), and Neighborhood Youth Corps (California) enrollees (22). . . . NASA certificate, given on completion of course, virtually assures employment as electronics solderer. (Contact/Ames, 1/75)

O-5 Nondestructive testing training manuals: developed for Marshall by General Dynamics Corp., Convair Div. (California). . . . used by Convair since 1967 as basis for commercial NDT training service. . . . 3-week course for 12 enrollees offered once a month; covers five major NDT areas. . . . tuition is $725 each, annual revenue to Convair about $100,000. . . . most students are management personnel from industries such as electric power, aircraft and NDT equipment. . . . students have come from 25 countries. (Contractor, TEF 14, Case No. 53871, 8/74)

O-6 Component degradation analysis techniques: developed by Marshall. . . . used in graduate course at University of Illinois. . . . NASA documents on failure modes and effects, as well as related R&QA topics, form major part of course bibliography. . . . NASA personnel from several field centers assisted professor in developing extensive bibliography. . . . 35 students have completed course and many now work in industry. . . . one of first academic courses offered in nation on prevention and analysis of system failure. (TB/TSP, TEF 474, Case No. 65764, 12/74)

O-7 Methods for using optical instruments: compiled by Marshall. . . . used at Milwaukee Area Technical College (Wisconsin) as text material in two photo-optical courses. . . . fulfills need for text on instrument techniques, providing students with better training. . . . two-year associate degree program . . . . graduates take technician jobs using high speed photography or holography with such companies as General Motors Corp. and United Aircraft Corp. (TB/TSP, TEF 529, Case No. 91985, 1/75)

O-8 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Central Washington State College Computing Center (Washington) to convert programs for new computer. . . . reduced conversion time and saved $1,000. . . . Center provides academic computing services. (Trade journal/TSP, TEF 527, Case No. 102158, 1/75)

O-9 NASA scientific and technical information: made available by Education Office at Kennedy. . . . used by Florida State University in several innovative education programs, as well as special libraries for student projects. . . . applications include an undergraduate course, an Industrial Arts Program in university's primary/secondary school laboratory, development of working models for use as teaching aids, and development of occupation descriptions for distribution to Florida county school systems. . . . since 1967, 200 students have taken the undergraduate course which presents R&D methodology by means of research projects. . . . 150 secondary school students currently involved in Industrial Arts Program where they learn R&D techniques by designing and building things such as fluidic circuits and motorbike heating systems. . . . teaching aid models for fuel cell, solar panel, and rocket car are being developed by program staff and Scott Engineering Sciences (Florida). . . . Scott will market the models as educational products. . . . descriptions of 150 different occupations, including astronaut, developed by university, with state funds, for distribution to 67 county school systems. . . . 25 industrial arts teachers from across the nation attended 1967, 1968, and 1969 summer institutes at Florida State University, with U.S. Office of Education funding, to explore use of space technology for industrial arts education. (Contact/Kennedy, TEF 311, Case No. 35912, 1/75)

O-10 Experimental multiple-use communications satellite (ATS-6): developed for Goddard. . . . launched May 30, 1974 into geosynchronous orbit. . . . provides high power density communication link from central ground transmitting stations to low-cost receivers in selected rural areas. . . . voice communication from receivers back to control center is established with inexpensive transmitter and ATS-1 or ATS-3 satellite. . . . used by HEW in Health/Education Telecommunications (HET) experiment for the delivery of such services to remote regions. . . . acting for HEW, the Federation of Rocky Mountain States (Colorado) coordinates experiments in Rocky Mountain region, Alaska, and Appalachian region. . . . as part of experiment, demonstration projects conducted by Federation, Indian Health Service (Alaska), Appalachian Regional Commission (District of Columbia), University of Washington's WAMI Program (Washington, Alaska, Montana and Idaho), and more than 15 other health and education agencies. . . . project applications include medical training, teleconferencing, and diagnosis; career education, continuing education, and in-service teacher training. . . . projects developed TV programs for the different applications. . . . for example, in the WAMI Program, satellite provides communication for medical education and conferencing between University of Washington medical faculty in Seattle and their medical students at universities in the four states, as well as doctors at rural Community Clinical Units scattered over 700,000-square mile area. . . . another example, 1,500 junior high school students at 56 remotely located schools in 8 Rocky Mountain states receive career education TV programs from Denver; students communicate between schools and with Denver instructor. . . . important educational benefits cited by students, teachers, and citizens in these remote communities. . . . satellite will be moved in 1975 to broadcast educational programs to 5,000 rural villages in India as part of that country's effort to reduce illiteracy. . . . U.S. groups now promoting development of educational satellite network. . . . more than 80 representatives from colleges, government agencies, publishing houses, and HET projects formed the Public Service Satellite Consortium to coordinate distribution of educational programs and to compile list of potential users for satellite network. (Interagency, TEF 530, Case No. 107035, 1/75)

Other Relevant Examples:

A-7 (optical training manual); F-6 (sanitary techniques training manual); H-9 and M-3 (NDT training manuals); N-5 and N-6 (insurance representative training); P-12 (reading tool for the blind)

Key Issue

Heart pacemakers: More than 50% of all deaths in the U.S. are due to cardiovascular diseases, which claimed over 1 million lives in 1974. By the early 1970's, heart problems had forced 3.6 million Americans to limit their activities. Heart pacemakers were introduced in the 1950's to rehabilitate patients with one type of heart problem: complete heart block. This is a malfunction of the neuroelectrical control system for heart muscles and is one of the major causes of fatal heart attacks. A pacemaker generates an electrical pulse that rhythmically stimulates the heart muscles to contract regularly. The three pacemaker components are: a battery-powered pulse generator, a stimulating electrode, and electrical wiring leads. In 1952, the first pacemaker was attached to the outside of the patient's chest. In 1958, a pacemaker electrode was placed, for the first time, directly inside the right ventrical of the patient's heart, and the electrical leads passed through the skin to an external pulse generator. Since 1960, the pulse generators have been implanted under the skin, outside the rib cage. Between 1960-1972, 120,000 pacemakers were implanted in Americans; 90,000 of these patients were still living in 1972. Some patients have such severe heart deterioration that 10-15% die within a year after the pacemaker is implanted. Those who survive the first year usually live at least 5 years. Pacemakers cost between $1,200 and $1,800 each. For most pacemakers, the battery pack or the entire pulse generator must be surgically replaced every 2-3 years. The replacement pack costs $200 and the operation costs $1,500. Recent advances in the batteries and circuitry for newer models have increased the replacement period to 3-6 years. Two new models increased this period even more: a radioisotope-powered unit (5-8 years) and a rechargeable unit (10 years or more). Two additional problems with most pacemaker designs are size, which has been too large for use in children, and malfunction due to microwave radiation. (P-5 and P-6)

P. HEALTH SERVICES/REHABILITATION

P-1 High purity, high strength carbon (processes to make vitreous carbon): developed for Marshall by Rocketdyne for reentry heat shields and rocket nozzle liners. . . . former Rocketdyne employee developed product line of rehabilitation devices now marketed as Biocarbon by Bentley Laboratories, Inc. (California). . . . material provides best available combination of strength, lightweight, and physiological compatability for implanted devices; combines with skin and bone to form permanent body plug-in. . . . TUO partially funded successful experiments at Rancho Los Amigos Hospital (California) to develop implant applications. . . . artificial limb attachment sockets implanted in bone; this direct skeletal attachment improves wearability of prosthetic devices (also uses release device originally designed for Saturn rocket release unit). . . . carbon socket satisfies long-term goal in artificial limb development. . . . also implanted in skin to pass wires through to implanted electrodes that relieve muscular pain by direct electrical stimulation. . . . chronic lower back pain relieved for nine patients in experimental program; major advance in ability to treat chronic back pain. . . . other clinical application experiments with Biocarbon include blood access devices, dialysis machine attachments, and catheters. . . . also used by Vitredent, Inc. (California) to develop false teeth for direct implant in jaw. . . . new product used in successful experimental application at University of Southern California School of Dentistry. (TUO-Applications Projects, TEF 59, Case No. 37428, 1/75)

P-2 Composite materials: developed by Langley for spacecraft, aircraft, and rocket motor applications. . . . used in two BATeams projects to design lightweight leg braces. . . . heavy, metal brace components replaced by molded composites. . . . prototypes tested at Coastal Center for Mental Retardation (South Carolina) and Mississippi Methodist Rehabilitation Center (Mississippi). . . . brace weight reduced by over 50%. . . . new braces improve mobility and are more attractive. . . . easier composite processing methods and cost reductions being developed to facilitate widespread availability of improved braces. (BATeams, TUO-Applications Engineering, 1/75)

P-3 Polyurethane-silicone plastic foam: developed for Ames Integral Passenger Aircraft Seat Program. . . . contractor employee formed Dynamic Systems, Inc. (North Carolina) to market the material under trade name, TEMPER FOAM . . . . BATeam identified initial medical application, bed pads for long-term patients. . . . caused sharp reduction in bed sores. . . . each bed sore increases hospitalization costs by over $5,000; medical insurance typically allows 25% of expected expense for spinal injury cases to be for bed sores. . . . BATeams assisted in developing other applications which now include wheelchair cushions, artificial limb socket lining, and finger splint padding for patients with hand burns. . . . treatment of burns thus improved. (Personnel/contractor, BATeam, TEF 570, 1/75)

P-4 Mobile Automated Metabolic Analyzer (MAMA): developed at Marshall as TUO project using Skylab astronaut monitoring instruments. . . . now used in experimental program to measure energy expended by orthotic-equipped patients at Spain Rehabilitation Center, University of Alabama School of Medicine, an HEW Social and Rehabilitation Services research and training facility. . . . patient walks beside instrument cart rather than on the standard treadmill which disabled patients cannot easily use. . . . provides real-time data, under realistic conditions, for respiratory gases, EKG and velocity. . . . previous monitors measured only cumulative data for gases. . . . new data valuable in evaluation of treatment procedures and patient-assist device designs. . . . also includes Lunar Rover technology in design of battery-powered cart. (TUO-Applications Engineering, 1/75)

*P-5 Nickel-cadmium battery technology: developed for Goddard by Johns Hopkins University (Maryland) for rechargeable spacecraft batteries (e.g., Small Astronomy Satellite). . . . used by Johns Hopkins to develop its patented rechargeable cardiac pacemaker. . . . six-year research effort funded by the University's School of Medicine, Baltimore City Hospital (Maryland), and Heart Association of Maryland. . . . Pacesetter Systems, Inc. (California) licensed by university to produce units. . . . first human implant for the product was in 1973; 1,200 implanted to date. . . . unit, with briefcase-sized recharger, costs $1,800. . . . provides rhythmic electrical stimuli to contract heart muscles and rehabilitate patients with intermittant complete heart block, one of major causes of fatal heart attacks. . . . rechargeable feature allows 10-20 years of reliable use, compared to 2-5 years for other units, before replacement surgery is required at a cost of over $1,500 per replacement. . . . weekly recharging takes 90 minutes . . . . patient anxiety about pacemakers reduced because recharger indicates whether unit is working properly. . . . current TUO-funded project at Goddard and Johns Hopkins to incorporate hybrid circuits in unit will further reduce unit's size and improve other features. . . . small size is required for children; improved cosmetic feature for adults. . . . new model will be implanted in 1975. . . . first total implant was in 1960; as of 1972, 120,000 pacemakers had been implanted in American patients. (Contractor, TUO-Applications Engineering, TEF 531, 1/75)

*P-6 Thick-film hybrid circuits and Mercury/zinc battery technology: developed for Goddard and Johnson by General Electric Co. (New York and Pennsylvania) . . . . used by GE to develop heart pacemaker product line. . . . over 4,000 units implanted since 1972. . . . current models provide 4-6 years of reliable electrical stimulation to rehabilitate people with certain types of coronary heart disease. . . . unit size reduced by 25% because hybrid circuits improve electrical efficiency by 45% and reduce interconnections by 50%. . . . recently improved batteries have 50% greater capacity than conventional mercury/zinc batteries. (Contractor, TEF 531, Case No. 106952, 1/75)

* Denotes transfer case related to Key Issue.

P-7 Artificial hand: developed for Marshall by Rancho Los Amigos Hospital (California). . . . includes unique finger control capability which enables amputee to pick up and operate standard power tools. . . . available commercially from General Teleoperators, Inc. (California). . . . important contribution to vocational rehabilitation for hand amputees. (Contractor, 1/75)

P-8 Control switch: developed for Marshall so immobilized astronauts could operate controls by eye motion. . . . BATeam developed digital controller (linked to eye switch) for rehabilitation environment. . . . Rancho Los Amigos Hospital (California) and Veterans Administration Prosthetics Center (New York) developed breath-actuator so that switch could be used with rehabilitation controller design. . . . allows paralyzed patient to control television set, book page turner, bed position, lights, and other objects . . . . prototype breath-actuated system developed with TUO funding at Huntsville Hospital (Alabama). . . . hospital project leader joined Scientific Systems International (Alabama) where he developed new product based on prototype unit. . . . product, called Nu-Life, sells for $900 to $4,000 per unit, depending on accessories. . . . higher price includes a miniature computer with capacity for 99 control functions. . . . 17 sold since March 1974. . . . product also generating interest by foreign rehabilitation centers and hospitals. (BATeam, Personnel/TUO-Applications Engineering, TEF 159, Case No. 108483, 3/75)

P-9 Horizontal shower: developed by Ames for use in long-term bedrest studies related to lengthy space missions. . . . unit consists of horizontal watertight compartment with multiple shower heads. . . . current TUO project to evaluate 2 design variations for bathing bedridden patients underway at Palo Alto Veterans Administration Hospital and Stanford University Hospital (both California). . . . commercial versions being developed at Diamondhead Industries Inc., (New Jersey) and General Teleoperators, Inc. (California). . . . sponge baths now administered by nurses are time consuming, difficult, and not thorough. . . . new shower design eliminates these problems and increases theraputic value of bathing. (TUO-Applications Engineering, 1/75)

P-10 Electromechanical stimulator modules: developed for Ames by Stanford Research Institute to obtain sensory feedback from remote manipulators. . . . used by former SRI employee to develop new reader for the blind. . . . Telesensory Systems, Inc. (California) founded in 1971 to market the new reader, called Optacon. . . . unit price started at $4,950 and is now $3,450; 1,100 units sold to date. . . . unit size is about the same as a small tape recorder. . . . in operation, handheld photodetector probe is passed over printed page and each letter shape can be felt through a matrix of mechanical vibrators on the 1/2" x 1" stimulator module surface. . . . Office of Education funded a large-scale program to evaluate Optacon. . . . 100 units tested by rehabilitation centers for the blind, including the National Center for the Deaf-Blind (New York), with favorable results. . . . the blind learn to use the reader in less time than Braille and can read most standard printed material with it. (Personnel/contractor, 1/75)

P-11 Hand physiotherapy device: developed by Langley in response to BATeam problem statement. . . . Langley prototype was field tested at North Carolina Memorial Hospital and Jackson Memorial Hospital (Florida). . . . redesigned prototype used successfully since January 1974 at North Carolina Memorial Hospital. . . . allows patient-administered physiotherapy for flexion and extension of finger joints; enables more efficient utilization of therapist skill and training. . . . alleviates contractures which may result from frostbite, burns, arthritis, orthopedic procedures. . . . manufacturing firms are interested in producing the device. (BATeam/Applications project, TEF 571, Case No. 109326, 4/75)

P-12 Semiautomatic inspection of microfilm records: developed for Marshall . . . . adapted by BATeam to develop prototype Paper Money Identifier (PMI) to help nonsighted people determine bill denominations. . . . design concepts used by EMR, Ltd. (California) to develop combination PMI and light detector product. . . . approximately 30 units sold @ $139; 10-20 units given to schools and foundations for the blind. . . . increases autonomy for the blind; also, expands career opportunities and reduces defraudulation. (BATeam/TSP, TEF 558, Case No. 109341, 5/75)

Q. HEALTH SERVICES/DIAGNOSIS AND TREATMENT

Key Issue

Emergency Medical Services (EMS) systems: The Emergency Medical Services Systems Act of 1973 provides assistance and encouragement for the development of comprehensive emergency medical services throughout the U.S. The goal of this act is to improve patient care significantly and to reduce morbidity and mortality. Current EMS systems include approximately 20,000 ambulances and 200,000 ambulance attendants. About 10 million emergency patients receive EMS treatment each year with 25%, or 2.5 million, being critically ill or injured. In contrast to a few years ago, critical patients can frequently be saved today if initial definitive and rehabilitative care is given to time and the patient is moved through the system to obtain essential services. For example, approximately 50% of all heart attack deaths occur within the first hour following the initial attack. When the heart attack is a cardiac rhythm disturbance, defibrillation within three minutes can lead to recovery for 72% of the patients. As a result of the 1973 act, local EMS systems are being improved through such actions as paramedical training for ambulance attendants and the use of more sophisticated ambulance equipment. (Q-1)

Q. HEALTH SERVICES/DIAGNOSIS AND TREATMENT

*Q-1 Emergency care system for ambulance use: developed for Johnson as part of STARPAHC, a cooperative program with HEW to provide health care in remote areas. . . . SCI Systems, Inc. (Texas) partially funded by Johnson to develop portable emergency treatment module, Telecare, to meet STARPAHC remote use requirement. . . . Telecare incorporates Skylab telemetry and medical equipment designs. . . . SCI produced commercial units for ambulance use: allow trained ambulance personnel to communicate with physician, transmit EKG data and provide emergency resuscitation. . . . unit used in several Texas cities, including Houston, San Antonio and Corpus Christi; also Montgomery County, Maryland and Altoona, Pennsylvania. . . . federal funding allocated to local government for emergency medical training. . . . SCI product line recently sold to Telecare, Inc. (Texas). . . . two models now available, Telecare I and Telecare II; unit price range $3,700 to $9,000, depending upon configuration. . . . Telecare, Inc. currently establishing international sales force. (Contractor, TEF 557, Case No. 108484, 4/75)

Q-2 Fluorometer instrumentation technology: developed for Headquarters, Marshall, and Electronics Research Center for diagnostic and Apollo instrumentation by Whittaker Corp. (Massachusetts). . . . used by Whittaker to develop new blood and urine lead detection device, Micro-Porph. . . . 10 to 15 instruments sol , current unit price approximately $3,000. . . . used by public health agencies, such as New York University Medical Center, Baltimore City Hospital, and St. Louis City Health Department, for mass screening of incipient lead poisoning. . . . permits low cost screening by unskilled personnel; 2-minute test costs approximately $1.00 compared to longer conventional lab test @ $5.00 to $8.00. . . . applications include people who live in areas with high lead pollution levels in the air and children who ingest lead-base paint. . . . estimated 400,000 children in U.S. affected by lead poisoning, with 200 deaths reported annually . . . . early detection can avoid permanent damage and death. . . . extent of lead poisoning a major factor in restrictions on lead-based paint and shift to unleaded gasoline. (Contractor, TEF 568, Case No. 109324, 4/75)

Q-3 Manufacturing contamination prevention handbook: compiled for Marhall . . . . used by Machlett Laboratories, Inc. (Connecticut), producers of diagnostic X-ray tubes for hospitals, as state-of-the-art reference source on contamination control. . . . resulted in improved product quality and higher productivity. (TB/TSP, TEF 544, Case No. 86664, 3/75)

Q-4 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Hollister, Inc. (Illinois) to solve major lubrication during design of new, automated equipment for colostomy bag production. . . . enabled company to identify a lubricant that would not contaminate product. . . . reduced labor costs. . . . 25 machines affected, with 1-2 million colostomy bags produced per year for hospitals and patients. . . . used by Richardson-Merrell, Inc., Merrell-National Laboratories (Pennsylvania) to solve major lubrication problem on Harvestor process equipment that extracts chicken egg fluid for vaccine production. . . . identified lubricant that reduced grease spills and satisfied stringent, sanitary quality control need. . . . reduced labor costs and machine downtime: increased production of vaccines. (TB/TSP, Trade journal, TEF 497, Case Nos. 91690, 92994, 4/75)

*Denotes transfer case related to Key Issue.

Q-5 Portable laminar airflow surgical clean room: developed for Headquarters by Martin Marietta Corp. (Colorado) for experiment in control of surgically induced infections. . . . installed for evaluation of St. Lukes Hospital (Colorado). . . . included state-of-the-art aerospace clean room technology, helmet and gown isolator system, and communication system . . . . used during 550 orthopedic surgical cases over 2-year period. . . . JPL evaluation of system effectiveness indicated personnel isolator system reduced contamination levels below those achieved with only laminar flow room and much lower than conventional surgical room. . . . major need exists to reduce postoperative infection associated with prosthetic implantation. (Contractor, TEF 577, Case No. 109323, 4/75)

Q-6 Heat pipe applications: developed for Lewis and Langley by Hughes Aircraft Co. (California). . . . used, together with aluminized mylar superinsulation, by Hughes to develop portable cryosurgical instrument product, Lewis Kryostik . . . . approximately 800 units sold since 1972 @ $1,000. . . . 2-lb. self-contained instrument supplies liquid nitrogen to cryoprobe tip for controlled destruction of tissue. . . . surgical applications include proctological procedures such as hemorrhoidectomies, destruction of malignant tumors and treatment of cervicitis. . . . allows 65% reduction of application time compared to other cryosurgical instruments. . . . compared to conventional surgical methods, advantages in Kryostik hemorrhoid removal are: no hospitalization, no anesthetic, less pain, faster recovery and lower cost. . . . experiments on lab animals indicate Kryostik stimulates auto-immunity to cancerous cells; positive results in 75% of cases studies. (Contractor, TEF 197, Case No. 109343, 5/75)

Other Relevant Examples:

B-2 (medical diagnoses); B-14 (medical instrumentation); N-5 (hospital sterilization procedure); O-2 (anesthesiology simulator); O-3 (birth simulator); O-10 (medical training and diagnosis by satellite); P-3 (bed sore treatment)

TRANSFER OVERVIEW

New technology generated by NASA programs represents a major addition to the nation's total reservior of technology. This section of the notebook presents an overview of the ways in which new technology is applied and, therefore, characterizes how the benefits presented in this notebook are derived from the use of NASA-generated technology.

Scope of Technical Innovations Reported

In-house and contractor R&D activities span more than 30 major technical disciplines in standard engineering fields. These activities have created a wide range of specific innovations including new equipment designs, techniques and technical capabilities. Some of these innovations were developed for direct applications in aircraft designs, weather forecasting, etc. Most of the R&D activity, however, has produced innovations for space applications which do not have direct analogs outside the space program and, therefore, require adaptation for each secondary application. NASA has also undertaken the development of selected secondary applications, the results of which often are innovations in their own right. All benefit examples from NASA innovations, regardless of why the innovation was developed, will be included in the notebook as these examples are identified and verified.

NASA has purchased off-the-shelf products for use in its programs. If this type of procurement activity did not cause product improvements or otherwise contribute to innovations in the product line, the product will not be included in the notebook.

Technology Utilization Modes

Benefits from NASA innovations occur when the technology is directly or indirectly used, rather than being potentially used. The technology may be applied, for example, in developing a new product which provides the manufacturer with increased sales and the customer with increased performance. The variety of applications and benefits is indicated by eight common modes that are used by organizations and individuals to acquire NASA technology:

Mode I: Diversification by firms producing for NASA programs through (a) shifts in production facilities and personnel to commercial product lines, or (b) implementation of formal organizational policies to apply mission-related expertise in commercial product development projects.

Mode II: General improvement of industrial production practice and product quality through NASA-initiated specifications and standards for mission hardware procurement.

Mode III: Development by industrial firms of new process or product technology, with NASA as the first market, and subsequent commercial production because additional markets and applications are recognized.

Mode IV: Relocation of skilled individuals from NASA-funded employment to employment in other economic sectors, resulting in the application of acquired skills to solve engineering or management problems encountered in the new sectors.

Mode V: Professional activities, including professional design code development, by researchers involved with NASA's basic and applied R&D programs.

Mode VI: Formal NASA programs that disseminate or adapt mission-generated technology for organizations in other economic sectors.

Mode VII: Direct access to NASA personnel or the Agency's scientific and technical information systems by other organizations as part of their normal information acquisition efforts.

Mode VIII: Interagency projects in which NASA adapts or develops technology for the needs of a second agency or the organizations that are aligned with the second agency.

This characterization provides a convenient context for understanding how NASA programs cause technological change in other economic sectors, as well as a basis for expanding the Agency's formal efforts to facilitate technology utilization. Continuing efforts by NASA to stimulate technology utilization have involved the deliberate use of Modes V through VIII.

Benefits Information

Economic benefits data are not presented in all of the notebook examples. These data are often proprietary. In general, however, individuals cannot estimate the proportion of organizational output that is attributable to the use of NASA technology. Economic data for individual examples rarely provide an accurate measure of the impact from NASA technical innovations. Therefore, each notebook example describes the technical impacts or benefits of NASA-developed technology, and specific economic data are included only when they are available.

The information contained in each example is verified and documented to assure reliability and accuracy on the date specified. Due to the time dependency of the data, the information will be periodically updated as appropriate to assure its current accuracy.

ORGANIZATION INDEX

Companies

Industry Associations

Federal Government

State and Local Government

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